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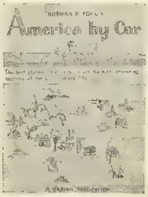

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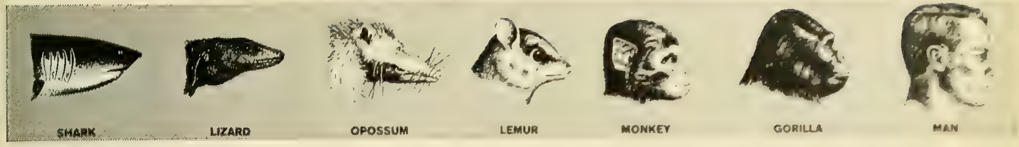

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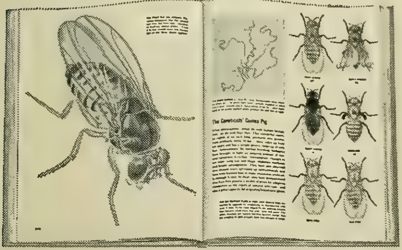

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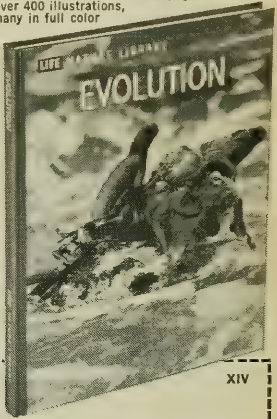

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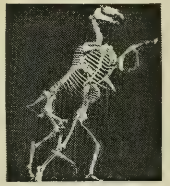

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COVER: Hong Kong Harbor, photographed here in moonlight by Burt Glinn, is one of the world's greatest and busiest ports. The harbor is also the home of more than 200,000 people who live and work aboard their colorful sampans and crowded fishing junks. Driven from the land many centuries ago, the *Shui-jen*, or water people, have developed a culture distinctly different from the South Chinese civilization on the shore. Their way of life, now being challenged by the modern world, is described by Dr. Wilmon Menard, starting on page 12. He lived in Hong Kong and has traveled widely in the Far East and the South Pacific.

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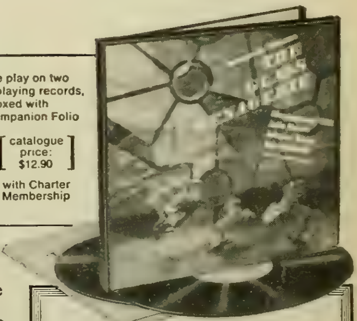

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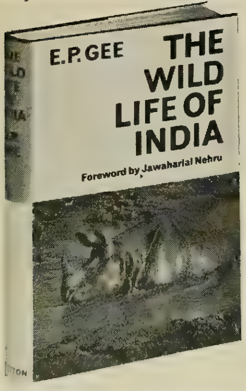

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BOOKS IN REVIEW

# "Oldest science" updated

### By James S. Pickering

THE FLAMMARION BOOK OF ASTRONOMY, prepared by Gabrielle Camille Flammarion and André Danjon. *Simon and Schuster, $22.95; 670 pp., illus.* WATCHERS OF THE SKIES, by Willy Ley. *The Viking Press, $8.50; 528 pp., illus.* THE PLANET MERCURY, by Werner Sandner. *The Macmillan Co., $3.95; 94 pp., illus.* MAKING FRIENDS WITH THE STARS, by Arthur J. Zadde, revised by Theodore A. Smits. *Barnes & Noble, Inc., $3.50; 144 pp., illus.*

SEVERAL astronomy books published in the last decade have been similar in form to *The Flammarion Book of Astronomy*. I must place this one at the top of the bookmaking heap.

Mark Twain once tried to describe the Taj Mahal. Words failed him and he wound up by giving only its dimensions. So it is with the Flammarion work. It is 11⅜ inches tall, 9 inches wide, and 2¼ inches thick. It contains 670 pages. There is at least one illustration per page and more than that on most. Many occupy a full page; some are in excellent color. Bare statistics, however, cannot begin to give the true impression of this magnificent book. It must be seen.

The text is complete in its coverage of astronomical events up to what must have been the last possible minute before publication. It even mentions those strange, recently observed anomalies known as quasi-stellar objects. It could not, of course, tell the story of the marvelous adventures of Ranger VII or the Russians' first multiple-passenger orbit. This situation is common with all books on astronomy and, I imagine, all other sciences. The law decrees that on the date of publication something strange and wonderful will occur and then it's back to the typewriter again.

This volume is divided into eight large sections called "books," each of which contains several chapters. Their titles will give a broad picture of the scope of the entire work: "The Earth," "The Moon," "The Sun," "The Planets," "Comets, Meteorites and Meteors," "The Sidereal Universe," "The Instruments of Astronomy," and "Space Vehicles."

Camille Flammarion was a nineteenth-century pioneer in the popularization of astronomy. His classic, *Astronomie Populaire*, has been used as the framework for the text and arrangement of this book. An impressive list of modern French astronomers, all internationally famous and all masters in their various fields, have revised and augmented the text that was prepared under the direction of Madame Flammarion and M. Danjon, Director of the Paris Observatory. I have explored their effort, looking for the pitfalls that have almost inevitably tripped editors in similar books, but have found no error or misinterpretation. The translation is uneven—perhaps because of the original text.

Flammarion was famous for his scientific honesty. Let me quote a passage as an illustration. "Who can assure us that astronomers cannot go wrong in their calculations? Who is to say even that they do not impose upon a credulous public? . . . Therefore, positive science, far from forbidding doubt, approves of it and tries to give it an answer."

To repeat, this is a magnificent book. If you have an astronomer—amateur or professional—in your life, and if you can afford it, get it!

Willy Ley's subtitle to *Watchers of the Skies* is "An Informal History of Astronomy from Babylon to the Space Age." I was stunned by the tremendous amount of research that must have preceded the writing of this book. It can be imagined that the author collected bits and pieces of information for years, possibly during the writing of a half-dozen other books on astronomy and on space.

From what must have been a most capacious trunk, he has dug out, organized, and assembled in an eminently readable style the story of man's gradual understanding of the universe.

The first section of the book covers early efforts to chart the sky, to account for the obviously cyclic motions of the objects seen, and to force these phenomena into various systems that would maintain the ruling central position of the earth and its inhabitants.

In the second section, the author takes the reader step by step from the discovery of astronomical instruments through man's attempts to grasp the true nature of his surroundings and the consequent crumbling of his egotistical, geocentric concepts. Every discovery within the solar system, every advance, every setback is recounted in minute detail, from Galileo's first sight of the four major Jovian satellites to the discovery of Pluto 320 years later. There is an amazing amount of minutiae in this section. How, for example, did Dante know of the Southern Cross, which he had never seen, and which had not been so placed that it could be seen by northern

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peoples for thousands of years before Dante was born? Willy Ley produces a sound and logical answer.

The third section tells of the investigation of the stars, which did not really begin until the middle of the eighteenth century. This part of the book is greatly outweighed by the two sections preceding it. At least, it does not contain details found in the earlier portions.

Finally, there is a short segment devoted to various completely impossible and unscientific theories of the nature of the universe that have been advanced, most of them in recent times.

There can be no doubt about the fascination of astronomy and of man's progress in this oldest of sciences, and Willy Ley has succeeded notably in projecting his own enthusiasm through the pages of his book. Many footnotes giving sources for much of the less familiar bits of information attest to the meticulous research behind it. There could have been more illustration.

On a more specific subject is Dr. Sandner's small book about a small planet. Mercury is the smallest planet in the solar system and is closer to the sun than any of the other planets. Because of the atrocious conditions under which it must be observed, it has been studied less than any planet except Pluto.

What little is known of elusive Mercury can be found here. Dr. Sandner gives a detailed account of the work of the few astronomers who have made most of the observations. The book's drawings bear witness to the lack of definition in even the most painstaking observations. Possible surface conditions, lack of atmosphere, and peculiarities of Mercury's motion are well covered. The language of the book is non-technical and the interested reader, even though he may not be versed in astronomy, has before him all the salient facts and probabilities about Mercury.

*Making Friends with the Stars* is a friendly, pleasant introduction to the small segment of the universe available to middle-northern latitude observers who do not use instruments. Mr. Zadde, author of the original version of this now-revised edition, devised a star chart that requires some study but is accurate —although somewhat overinvolved. The updating of the book by Professor Smits could have been more thorough. For instance, the book, originally published in 1948, still refers to certain stars being common to two constellations although this situation was corrected by the Delporte Commission in 1932. A recent revision of stellar magnitudes is overlooked in one section and used in another.

These are relatively minor defects, however, and do not detract sufficiently from the charm of the book to destroy its usefulness.

*Mr. Pickering is Assistant Astronomer, The American Museum-Hayden Planetarium. "Asterisks," his latest book, was published by Dodd, Mead and Company.*

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IN THE BEGINNINGS, by H. R. Hays. *G. P. Putnam's Sons, $10.00; 575 pp., illus.*

THE author of *From Ape to Man,* H. R. Hays, has now produced a volume on early religion. The book, subtitled "Early Man and His Gods," covers both prehistoric religions (Paleolithic Europe, the ancient Near East, Neolithic to Iron Age Europe, the Indus Valley, Bronze Age China, and ancient Egypt) and the religions of modern non-literate peoples in Africa, Oceania, and the Americas. The subject is seen through the eyes of traditional descriptive anthropology combined with selected concepts from "depth psychology" as expressed by Roheim, Freud, and others.

"The study of early religion involves the investigation of all of man's psychic life," says the author. What is religion? "Religion is not only a technique for obtaining practical benefits, it becomes a solace for the deepest anxieties." It "unites the social unit, channelizes human anxiety into aesthetic forms and lends poetry and meaning to man's conception of the universe and himself." In

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short, the book is about the non-scientific adjustment of man to his world of emotional anxieties. Since this world of anxieties is all-encompassing to primitive man, all of his activities are partially religious in nature. Thus any study of "early religion" necessarily involves a study of man's activities beyond mere myths and incantations. Hays sees the primary concerns that underlie these activities as centering in one way or another upon sex—desire for sexual prowess, fear of castration, desire of the older generation to subdue the younger challenging males, battle frenzy, sexual sadism, and so forth. This emphasis on the sexual side of man's religious activity restores an important aspect of the subject long suppressed by Victorian attitudes. At the same time, the sharp emphasis on it, almost to the exclusion of other considerations, suggests that sexual concerns currently prevalent in our own society are too conspicuously represented to provide an undistorted view.

It is inevitable in a book of such scope that some materials will not be entirely up to date, and such is the case with some parts of *In The Beginnings*, especially the chapters dealing with the Sumerians and the Indus Valley. Hays attributes to the Sumerians the founding of cities and the formation of the irrigation system in southern Iraq. Yet there is considerable evidence to indicate that this population was non-Sumerian. The linguistic term "Sumerian" has meaning only with the appearance of the language in written form during the Jemdet Nasr period, *ca.* 3000 B.C. It is to the following periods that developed cities and the Royal Tombs at Ur belong, not to the fourth millennium, as stated in the text. Although writing precedes the Jemdet Nasr period (appearing with cylinder seals but not demonstrably "derived from" them), there is uncertainty as to what language was being written.

A further refinement of our understanding of the fate of the Indus Valley civilization is also possible. It was once thought that it came to an abrupt and complete end, but we now know, through recent work in Pakistan and India, that only the area around Harappa was destroyed. In southern and southwestern regions (as far south as Bombay) it carried on right into the Iron Age without interruption. There is thus good archeological evidence now available on which to argue a considerable carry-over of Harappan ideas into historic India (as the author has already suggested on other grounds).

A book that makes people think is always welcome, even with its errors: new insights are suggested, new perspectives are drawn, and, at the very least, specialists are roused from their slumber to a reconsideration of the issues. This book is successful in just this way. It is provocative, well written, and comprehensive. It makes both enlightening and entertaining reading, at the same time challenging the reader to think about the nature of man's early gods.

ROBERT H. DYSON, JR.
*University Museum, Univ. of Penn.*

SCIENCE IN ARCHAEOLOGY, edited by Don Brothwell and Eric Higgs. *Basic Books, Inc., $17.50; 595 pp., illus.*

ARCHEOLOGY has a new climate—scientific interdisciplinary co-operation and research. The editors of this volume have advanced this climate admirably by collecting articles of specialists in a variety of fields—all focused upon their relationship to archeology. They have achieved the prime objective of their volume: "to provide a systematic conspectus of the bearing of the natural sciences on archaeological investigation."

The book is divided into five areas: Dating, Environment, Man, Artifacts, and Prospecting. These divisions contain a total of fifty-four selected articles focusing attention upon specific aspects of each topic. No real attempt is made to correlate, or even to relate, the individual articles—an approach that I highly applaud. Rather, the reader is plunged into each individual author's specialty. A general introduction assists in orienting the reader to the articles that follow under the specific headings.

The division on dating is composed of eight articles that cover the latest technological advances available from the physical sciences for chronometry, ranging from bone dating to measurement of the ages of ceramics. The section devoted to environment is the largest in the volume, as might be expected. Subdivisions on climate, soils, plants, and animals manage to touch upon all possible areas of interest to the anthropologist-archeologist today. Perhaps the prehistorian may find this section of the book more to his taste than will the historical archeologist, but the emphasis on technique, collection methods, statistical and other evaluation should be of interest to both. These thirty-five articles emphasize the non-morphological aspects of modern science, and place great stress upon sociological problems, field methods, and practical expedients from which the archeologist in any area may learn much.

The study of man has a full dozen articles devoted to methodology and evaluation techniques; the physiological aspects of investigation are heavily accented. At least three of the articles (by Genovés and Wells) may cause a serious re-evaluation of approach in anthropological circles. Once again, technique is stressed to good, practical advantage.

In that area of artifacts and their evaluation, the reader is only treated to a glimpse of the newest techniques, with a

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few unfortunate omissions. However, the standards of the rest of the book are maintained, and the section moves from petrology and spectroscopy to fiber identification. Here, also, the major accent is upon methodology.

The final division of the book contains only two articles on prospecting, which one might have anticipated finding at the beginning of the list. Surprisingly, however, the subject fits into last place quite logically. In these two discussions, the reader is treated to one of the finest summaries of modern survey methods to be found in print. Happily, neither the bizarre nor the "special purpose" gadgetry obtrude into the discussions of physics and subsurface detection devices. Unhappily, a few interesting areas of detection-survey technology were omitted.

The bibliographies for every subject area are appended to each article. This feature further enhances the value of the material included in the volume itself. The photographs and drawings are excellent, the tables and charts are informative, and the indexes are most helpful and complete. It must be noted that this is a reference and source book, not a collection of manuals. As such, however, it will become a mandatory background work for professionals in the field of archeology. Some mild provincialism is evident, but this does not detract from the general value of the volume. The lively differences of opinion found here and there among the contributing authors serve as a warning to all that the latest word is yet to come in every scientific field—but that interdisciplinary liaison and teamwork have become the archeologist's best friends.

PHILIP C. HAMMOND
*Princeton Theological Seminary*

THE NATURAL HISTORY OF MAMMALS, by François Bourlière. *Alfred A. Knopf, $6.95; 387 pp., illus.*

FRANÇOIS BOURLIÈRE'S *The Natural History of Mammals*, now revised, was first published in the United States in 1954, beautifully translated from the French by the late H. M. Parshley. The clear, thoughtful text, and the amusing as well as instructive drawings by Paul Barruel, brought the book immediate recognition among zoologists. It remains the best general summary that we have, from a world point of view, of the behavior of mammals.

Bourlière has aptly called his book a "natural history." With this title, he can relate behavior, environmental conditions, and general physiology in a way made difficult when such special terms as "ecology" or "comparative psychology" are used. For me it is cheering to see the idea of natural history as science gaining increasing scholarly acceptance in recent years.

The book starts with locomotion: walking, running, galloping, leaping, brachiating, swimming, gliding, flying. The number of ways that different mammals have developed for getting about in the world is astonishing. But locomotion, as Bourlière notes, "is in a way the fundamental activity of an animal, that which conditions most of its other activities, and in particular the search for food and for a mate. Parallel with the structural modifications of the skeleton and the muscles, therefore, one must expect to find physiological adaptations of the nervous system, the sense organs, and behavior. . . ."

Bourlière goes on to discuss mammalian food and feeding habits, territory and home range, defense, reproductive behavior, growth, migration, social life, environmental relations, and finally population dynamics. The text is clear and simple enough to be understood by any interested reader, yet is sophisticated enough not to cause raised eyebrows among the experts. Over and over again the author underlines our ignorance at the same time that he summarizes our knowledge so that, in reading the book, one is constantly aware of how much we have yet to learn about these animals. It is, in short, a book that should have a place in every nature library.

The text has been revised to include the results of the more significant investigations published in the last ten years. For the most part, the changes are rather minor, but the last chapter, on "The Structure and Dynamics of Natural Populations," has been completely rewritten. An appendix has been added on "certain eco-physiological problems," which covers, necessarily in a rather sketchy manner, aspects of perception (vision and smell), activity rhythms, and daily food intake. The bibliography has been enlarged and rearranged, with a cross-index by topics that should increase its usefulness.

MARSTON BATES
*The University of Michigan*

ULENDO, by Archie Carr. *Alfred A. Knopf, $5.95; 258 pp., illus.*

DR. ARCHIE CARR, a Professor of Biology at the University of Florida and also a Research Associate in Herpetology in The American Museum of Natural History, is perhaps best-known for his researches on marine turtles. He has traveled extensively in Central America and Africa. Fortunately for the general public, besides being a capable scientist he is also a very gifted writer, as *Ulendo* (which means journey in Chinyanja, a language spoken by natives in Nyasaland) abundantly proves.

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Dr. Carr has made four journeys through Africa. On the first one he went to hunt snails and mosquitoes that are intermediate hosts for diseases that affect the natives of Nyasaland and Mozambique. His later trips made him realize the appalling changes that are occurring throughout Africa, and because he understands the great need for conservation, he devotes many pages of his book to the problem.

Dr. Carr is an ardent theorist, and much of this book is made up of descriptions and explanations of interesting phenomena he has encountered, such as the vast swarms of midges on Lake Nyasa, the queer distribution of the cichlid fishes in the lake, and the increase of the cattle egret throughout the world.

*Ulendo* is an interesting and very readable book.

T. DONALD CARTER
*The American Museum*

THE ROCKS REMAIN, by Gavin Maxwell. *E. P. Dutton & Co., $4.95; 209 pp., illus.*

BOOKS written about tame wild animals generally fall into one of two classes: those written by zoologists, which are often readable but uninspired; and those by professional writers, who too frequently produce works that are abhorrent to the zoologist. Gavin Maxwell is a professional writer, but he is also a careful reporter, and his narrative of the exploits of his two African clawless otters, and later his pair of Eurasian otters, provides information that is of scientific interest; it is also entertaining.

Those who expect this sequel to *Ring of Bright Water* to deal only with animals will be disappointed; the story often leaves them to range from an account of the recent earthquake in Morocco, to a boatwreck, to the theft and destruction of the author's sports car.

In another respect, too, this book is not like its predecessor. The otters here are not always endearing and this book will not inspire the uninitiated to seek a "pet" otter.

It is considered good form for a reviewer to take exception with at least one item in a book, but despite several years of having lived with otters I am unable to question, from the standpoint of zoological credibility, anything in Maxwell's narrative.

JOSEPH A. DAVIS, JR.
*N. Y. Zoological Park*

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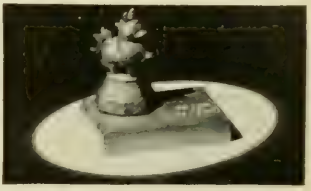

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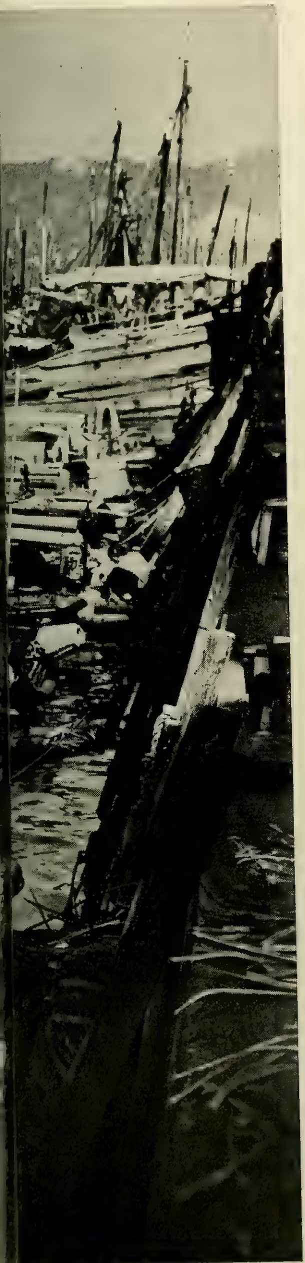
# The Sea Gypsies of

# China



*Hong Kong's crowded harbor has long been the home for the Shui-jen people.*

*Traditional junk has flat lines with a high poop deck and overhanging prow.*

## WATER IS THEIR DOMAIN

I first saw the sea gypsies of South China, the *Shui-jen* (water people), from the forward deck of a liner that was approaching the rocky islands that guard the entrance to Britain's Crown Colony of Hong Kong. The flotilla of careening, high-pooped junks and purse seiners suddenly appeared like a Chinese armada of a thousand years ago, with huge, single lugsails flapping in the variable wind. Some showed the white wake of auxiliary marine engine propulsion.

A British resident of Hong Kong, an importer, handed me his binoculars, remarking: "Fishing junks manned by the best seamen of the Orient—the Tankas, or *Shui-jen*." I brought one of the boats into sharp focus and could see the activity on deck—men, women, and children moving with effortless precision to perform nautical duties older than those of the Norsemen.

As we moved up the heavily trafficked Victoria Harbor of Hong Kong, I saw that the vessels moored to buoys in the center were surrounded by small junks and one-masted lighters, the aristocrats of the Tanka fleet, whose owners enjoy a measure of social respect according to the type of cargo loaded into their holds or on deck for discharge ashore. The wide "roadstead" was congested with Chinese craft of every conceivable design and color of sails, seemingly guided, or *yu-loh*-ed (stern sculled with a long sweep) on erratic courses that only narrowly missed the freighters, passenger vessels, and Star ferries, which moved like busy ducks between Hong Kong Island and Kowloon.

I later discovered that the sea gypsies of South China purposely cut closely to larger boats because they believe that this transfers their "bad luck devils" into the custody of foreign ships—a hazardous custom that occasionally results in some of them getting run down.

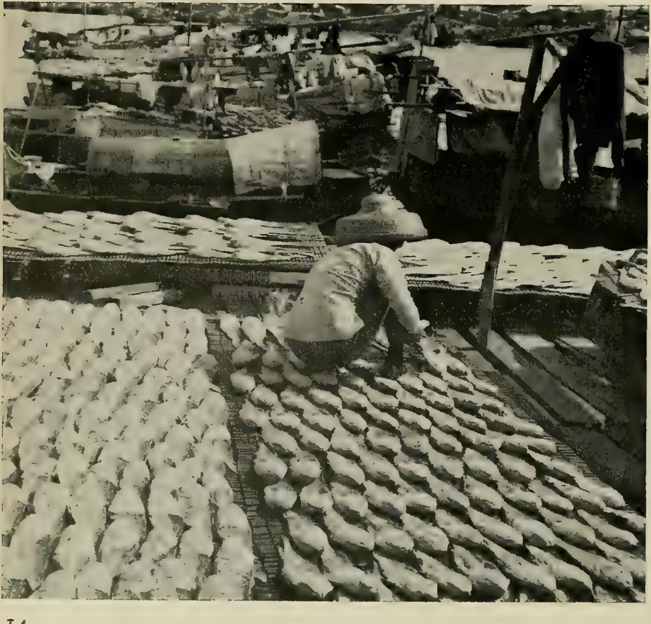
Now and again I glimpsed a three-masted junk, the imposing "long-liner" of deep-sea travel and fishing, with a sail set well forward of its huge mainsail, where one would normally expect to see a jib on any other craft. Some of the sails were so fantastically mended that they resembled a grandmother's patchwork quilt rigged in sudden emergency; others were so ravaged by wear or wind that it seemed incredible that the rent sails could hold wind —yet these cumbersome craft sailed.

Many times junks and seiners look

### *by Wilmon Menard*

*Sampans (above) ferry people and cargo between the junks and the shore.*

*After a fishing journey, the Shui-jen spread their catch on mats at pier.*



alike, but the long-liner junk of deep sea travel is the largest, of course. A seiner is usually a diminished version about 35 to 40 feet long. The lighters. which appear in many forms, are often converted from small junks and afford more space on deck and in the hold. Other lighters are similar to the level-decked Malay proa, which is without the high rise of the traditional high-pooped junk. The colorful sampans, 9- or 10-foot boats that are used by the purse seiners as dories, are distinguished by a half-circle ribwork and awning over their midsection, and can be sculled by a single person.

ONCE ashore in Hong Kong, one of my first interests was the sea gypsies. I learned that they are not pure Chinese. There are many theories about their origin, perhaps the most supportable being that they were the traditional and centuries-old "water people" from the deltas of Kwangtung Province of South China, who later settled as far north as Shanghai. They apparently were forced from the deltas onto the sea by the land Hakkas from Central China and the Indo-Chinese ancestors of today's Cantonese. My own studies lead me to think that their point of origin may have been India, from where they migrated to South China. In any event, they have, in the latter part of their long history, rarely settled ashore. They own large seagoing junks and control deep-sea and coastal fishing. Ancient Chinese laws once forbade them to intermarry, to come onto the land to settle, or to be eligible for the Imperial Examination, which was the only way that one could rise above a low caste. But during the reign of K'ang Hsi (1662-1723) the land ban against the Tankas was relaxed and they were permitted to build shacks on the waterfront. However, acquiring an education or marrying into another caste, such as the Hakkas or the Hok-lo (a fishing and agricultural group), was still taboo.

Because of these prohibitions, the Tankas have been for centuries an outcast people, largely illiterate and racially exclusive, but fiercely proud. The land people of South China gave them the nickname Tankas, or *Tanmans*, which literally means "egg families" or "egg people," insinuating that they float like eggs in a sea, without purpose or direction, propelled only by the wind, waves, and currents. But students of Chinese claim that the

*Today, a Shui-jen mother may bring her child to a doctor on the shore, although historically all water people have been suspicious of land people.*

Chinese "egg-character" traditionally applied to them was meant only to represent the sound of the term designating water people. The sea gypsies do not like to be called Tanka, because they consider it abusive. They might employ it jokingly among themselves, but resent an outsider using the term.

The water people are still disinclined to settle ashore, and have an inherent suspicion and distrust of land people. They have a saying: "We always sail away from 'land troubles.'" (However, at Tai-o, on Lantao Island, near Hong Kong, I found a large group living ashore—or rather partly ashore, because their primitive huts were constructed on pilings over the inlet.)

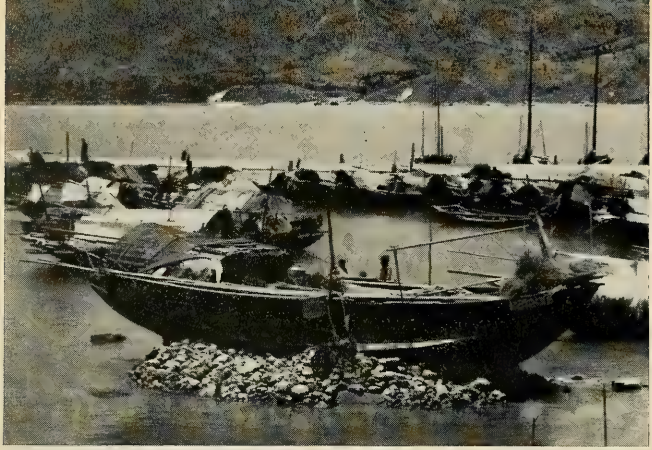
Until the Chinese Revolution of 1912, the land people of South China shunned them, and if there was a rare instance of a Tanka child being born to one of their women, it was immediately put to death and cast into the sea. The water people did not deserve this ostracism, however, because they were then, as today, a peaceful and an industrious race. Originally, they spoke a non-Chinese language, conceivably Malay, which was then gradually corrupted by Hakka, Hok-lo, and Cantonese. Today they speak a crude Cantonese dialect that they adopted early in the fourteenth century during the Yuan Dynasty.

There has not been an official census taken by the Crown Colony government for a long time, but a population estimate of the Tankas, whom I shall refer to hereafter, out of respect, as the *Shui-jen*, is close to 200,000. Half of them are fishermen, and the rest engage mainly in trading and in cargo and passenger transportation.

The *Shui-jen*'s prestige is vested in his large, seagoing cargo and fishing junk, or purse seiner, or his bulky lighter, called *kam sing ten*, to be seen every day banked close to the hulls of freighters. Some also own the colorful sampans. The *Shui-jen*'s capital is invested completely in his vessel, and if he must borrow money to make repairs or modernize, he makes certain that his creditor belongs to a member of his allied family. He takes no chances of losing his floating home—which, if large, might accommodate up to a hundred people—by borrowing from a crafty moneylender ashore.

With this great responsibility, it is easy to understand why the *Shui-jen* master, or family head, controlling as many as four generations of his family aboard the junk, cannot act hastily or listen to concerned government welfare workers who keep insisting that he send his children ashore to schools for a formal education.

His challenge to the "land meddlers" might well be: "Will reading out of books and learning to count make my son a better seaman, or my daughter a better cook and more nimble with her fingers in repairing clothes or torn sails and nets? An education in some school ashore would make my children wary of this life we lead; there are schools here in the shelter where they can learn the simple, necessary things. On this ugly, unpainted junk we were



*To position a boat for repairs, the Shui-jen anchor it over a rocky base at high tide. Then, when the tide is low, the craft is in solid dry dock.*

born, we work, eat, and sleep—and die. The sea is our world, the fish our quarry. It has always been so with us. It is our survival."

A more specialized craft, perhaps more adaptable to the *Shui-jen*'s work, might upset the order, customs, and discipline to which generations of his ancestors have been accustomed, and change is not easy for these people. If one bought a junk with a diesel engine, neither the master nor his sons nor grandsons would be technically qualified to act as engineers, so some outsider would have to be hired. Yet, to survive, the *Shui-jen* must work on a purely family basis. A stranger on board could drive a serious wedge into the once-perfect family unity, and the economy would be weakened.

I was to spend many days being sculled along the watery labyrinths of the junk shelter formed by the moored junks and sampans. Wide, open channels run the length of this "world on the water," bisected by narrow waterways—gray-black canals of polluted water from which a sulphurous stench rises from centuries of contamination. The entire surface appears to be a pestilential flow of garbage and excrement. Yet the *Shui-jen* children splash, dive, and play happily.

Sampans and bumboats (long, open dories) manned by the *Shui-jen* deliver fresh water, firewood, vegetables, and groceries to the junks. The *Shui-jen* have their floating dry docks for scraping and repairing hulls; their coffinmaker (they have always had interment ashore); a yodeling postman; an ancient fortuneteller; and their aquatic quack to dispense mysterious pills, powders, and elixirs to those who may be ailing. On small junks with top-heavy verandas, the *Shui-jen* can drink and listen to radio or phonograph music. They have the boat schools and, of course, the customary double row of sampans with pretty prostitutes in the stern calling softly to passing boatmen and tourists. And every junk and sampan has its Buddhist or Taoist shrine, with burning joss sticks, paper flowers, and effigies that hold the revered family tablets. It is, indeed, a complete world.

The more time I spent among the *Shui-jen* of Hong Kong, the Kowloon typhoon-shelter harbor inlets, and the numerous anchorages in the New Territories and adjacent islands, the more I came to admire and respect them for their happy, industrious, patient dispositions, which permit them to live in primitive, close-packed harmony on their small craft. Everything is shipshape aboard, even though every inch of space is taken up by family members of several generations. The scenes of routine activity are always pleasant and diverting: the mother (whom everyone worships) squatting with her daughters tending open galley fires, scrubbing pots, and preparing food; the father and master of the craft attending to or overseeing major repairs and adjustments to rigging and sail and seine; the eight-year-old daughter spreading washed clothes over a boom to dry and at the same time keeping a vigilant eye on a crawling infant to be sure it has not slipped its waistcloth and line and is not in danger of falling overboard; the young son swabbing down the deck. All of this is carried out without bickering, interference, or carelessness.

Because of their inherent distrust of land people, it is not easy to make friends with the *Shui-jen.* It was only through the efforts of a Kowloon fish-dealer that, after a few months, I was finally accepted as a "foreign friend" by Li Hsuan, called The Old One, the 70-year-old master of a 35-foot purse seiner, or *ku-chai*—one of 2,000 or more based in local waters. His vessel had a foresail installed where Western craft commonly carry the jib, and its beam was broad and heavy and drew about three feet of water, allowing a clearance of a little more than two feet when fully loaded. It had been constructed of fine fir and teak many years before at a cost of about $750. The foredeck of the *ku-chai* was occupied by the seine, a large net of fine mesh, which permits no fish, regardless of size, to escape. Behind the mainmast the space on deck was given over to living quarters. Three arched sections had an awning with canvas sideshields that could be lowered to exclude gusts of wind or driven spray.

Li Hsuan's quarters were forward, and just behind were the communal family areas for two other generations—a total of eighteen people. Adjacent was the tidy galley, and behind was just sufficient space on the poop for the helmsman. The bedroom awning amidships was so arranged that it could be dismantled at a moment's notice to accommodate the sweeps, or *yu-loh*—the oars for sculling. Judging

*Past generations wove cotton or ramie nets. Modern Shui-jen boy uses nylon.*

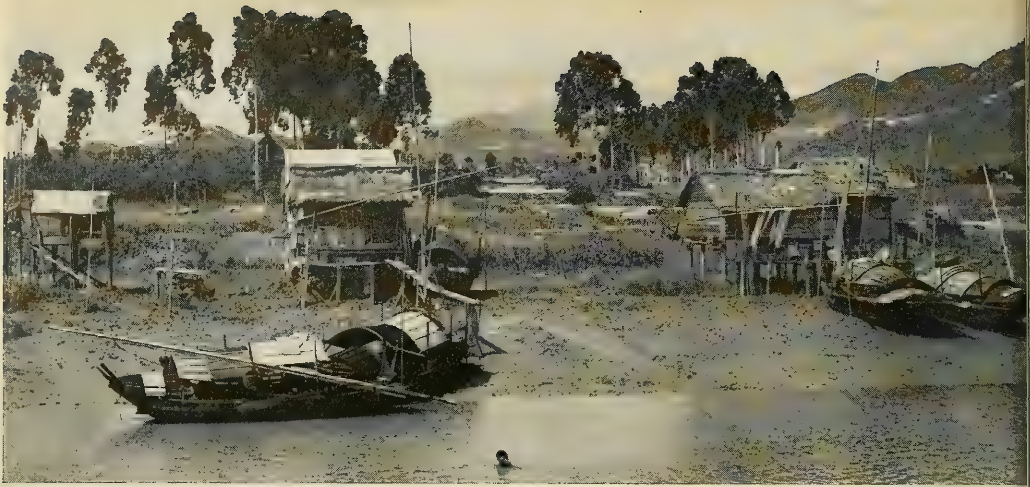
from the muscular legs and arms of the family, this form of propulsion is the most consistent with the *Shui-jen.* During rainy weather, when all the awnings are installed, one cannot stand erect, and passage to the galley is made on hands and knees.

One afternoon, when I came aboard to visit The Old One, he was squatting on the projecting wooden platform at the stern, glaring wrathfully toward the mainland of Kowloon. Through a son-in-law, who spoke some English, I asked, "Where are the young folk?"

Li Hsuan gestured toward the waterfront of Kowloon and said: "At a movie house on Nathan Road watching an American dance contest performed by land people teen-agers! The

*Woven nets (above) are hung up to dry in the rigging of a purse seiner.*

*Fisherman sculls his loaded sampan with two long oars known as sweeps.*



*Although banned for centuries from settling on shore, a large group of Shui-jen now live in huts built on pilings over an inlet on Lantao Island.*

*Swimmer risks his life (above) to get first choice of fish before the launch docks. On the pier (below), the catch is unloaded for sale in the market.*

last war changed many things for the *Shui-jen*. Now even my sons and daughters overrule me when I try to keep the rebellious ones away from the influence of the land people who conspired against us for centuries."

This is partly true. The younger generation of the *Shui-jen* are gradually discarding the ancient belief that they are a race apart, jettisoning rigid customs, and adopting the more diverting practices of shore dwellers. Today, the *Shui-jen* take advantage of the Crown Colony's free medical services, although in the past they would never have dreamed of consulting a land doctor. Once babies were delivered by the head of the family on shipboard. Today the women go to the maternity ward in Kowloon. But when the mothers return from a shore hospital with their infants, most of them still adhere to an old *Shui-jen* custom: the mothers must be picked up by the family junk, for it is considered bad luck to be taken out in a sampan.

The children of many of the *Shui-jen* are succumbing to the benefits of shoreside schools, and even though The Old One was fierce in his opposition to change, he had, under pressure from his daughters, reluctantly allowed his second wife (concubinage is permitted in the Crown Colony of Hong Kong, although forbidden in Taiwan and Communist China) to move ashore into an apartment, where she acted as a sort of agent to arrange contracts for his fish hauls and, if the purse seiner had not returned from a fishing cruise, as custodian of the children returning from the boat school.

The Old One's resistance to modern influences had weakened in other ways, too. For instance, he would study pictures in booklets published by the Fisheries Research Unit of Hong Kong University. A son-in-law explained the texts to him, and he was particularly interested in one that advocated using nets made from nylon monofilament instead of the too-fine seines of cotton and ramie that were depleting the sea of young fishes and ruining fishing prospects for seasons to come.

The young and pretty daughters of the *Shui-jen* likewise stray more and more ashore. The colorful shops along Nathan Road in Kowloon, filled with dress goods and sundry trinkets, lure them—and, to buy, they sometimes sell themselves to seamen from cargo and passenger ships docking in Kowloon. Since ancient times, landsmen have considered the women of the *Shui-jen* to be highly immoral. Their wantonness, however, has been confined to their own floating world. Most of the Tanka couples in the junk shelter never marry and the women are fickle. Incestuous relationships, attendant to the crowded conditions aboard junks, sampans, and purse seiners, are commonplace. Unwanted children, particularly girl babies, once were dropped into the sea, or were sold ashore. This practice, although prohibited by the Hong Kong government, is still carried on surreptitiously.

DURING the postwar period the water people made their first significant contacts with foreign civilization, compelling them to discard some of their taboos. Largely, these contacts consisted of open fraternization with landsmen following the liberation of Hong Kong from the Japanese. For instance, with the huge profits they had derived from carrying cargo between ships and godowns (warehouses), the *Shui-jen* could afford to patronize the expensive restaurants in Kowloon. Apparently, considerable havoc was caused when the family of The Old One perched on their heels on the edges of the chairs or sat on the tables with their feet in the chair seats of an exclusive hotel dining room in Hong Kong.

Fortunately, the more important and basic traditions of the *Shui-jen* have been retained. The hygiene aboard is excellent, and clothes, gear, quarters, and deck are kept scrupulously clean. In addition, the *Shui-jen* dispense order, charity, and justice through their self-governing councils. Their only legal rebuke from the land seems to stem from overloading their craft with passengers, or from accidentally colliding with another boat in the harbor. Even then, although the harbor master will sit in on the resultant hearing, the *Shui-jen* settle such problems in their own particular manner and time, and according to their own strict code of etiquette.

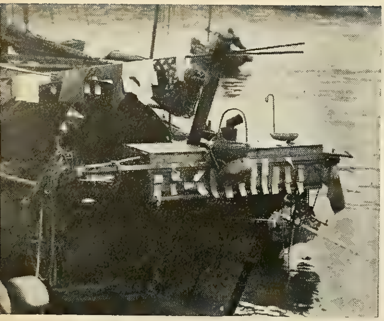
There came the day when the friendship between The Old One and his family and myself finally progressed to the point where he accorded our relationship the greatest honor: he invited me to accompany them on a fishing voyage, which was to include his junk and that of his nephew.

The real work of the purse seiners of the Hong Kong fishing fleet begins before sunset, just after the evening meal and wash-up. Aboard Li Hsuan's craft, dinner was prepared by the youngest wife in the family and was eaten on the open prow. Then, with the nephew's purse seiner ready to leave, The Old One gave the order to cast off.

Night overtook us beyond the headlands of Hong Kong, and the scattered rocky islands merged with the darkness. Forward, the eldest son played his flute, and others joined in with stringed instruments, percussion blocks, and cymbals. We arrived at the fishing grounds about midnight, and the sampan from each purse seiner was lowered over the side, its reflector-type lamp illuminating the depth to attract the shoals of fish. The two purse seiners then sailed in opposite directions and began to circle widely around the two sampans in the center, the nets being paid out from their foredecks to encircle the area completely. There were usually two men to each sampan, one sculling and the other beating the water with wooden blocks or illuminating the water with lamps to draw fish into the seine.

Then, at a shouted signal from The Old One, the seiner crews began to draw in the purse line connected to the lower meshes of the seine to close the gigantic sea pouch, while the men in the sampans hauled gradually on either end of the surface mesh. The sampans,

*William Kinkade, of the Oriental Boat Mission, entertains Shui-jen children with his trumpet, operating the valves with a monkey-puppet glove.*



*Paper prayers pasted on boat's stern wish both family and craft good luck.*

sculled strongly, now shot smartly outside the diminishing net circle, the men yodeling loudly and beating the water's surface. Then the sea pouch was hauled in by the two junks. This circling and hauling operation took about forty-five minutes and was repeated several times. The catches were far above average, so the crews were in a festive mood, and with traditional *Shui-jen* politeness, they said they were sure that my presence aboard had brought them good luck. Just after dawn, the sampans were hoisted on deck, the junks raised sail, and we set a course back to Hong Kong.

While we were sailing into Hong Kong Harbor, a Chinese swimmer grabbed our tire fender and nimbly scrambled up over the side to the deck. Around his waist was a net. He was one of the many advance scouts hired by fish-stall owners of Hong Kong Island and Kowloon to board purse seiners ahead of the dockside buyers in order to have the first selection of the best fish. This is a dangerous occupation, and sometimes, with diesel junks or fast motor launches that are traveling too rapidly, the swimmers miss their grab and are swept back into the propeller blades. But because they are poor, young boys take such risks every morning, and they say that they prefer to die that way, if it is to be their fate, rather than to starve.

INSIDE the junk shelter, The Old One gave the order for incense to be burned at the bow as an offering of thanks to Tin Hau, the Queen of the Heavens, who is the patron saint of the *Shui-jen*. As with fishermen the world over who contend with the changeable and mysterious sea, the *Shui-jen* are deeply religious, and the majority of them are Taoists. Aboard Li Hsuan's junk the shrine to Tin Hau occupies a major position in the port cabin, with a light always burning in front of it.

*Lyemun Island temple statues are of Tin Hau, patron saint of Shui-jen.*

*Evening falls as boats sail out fro Victoria Harbor on a fishing voyag*

During the Chinese New Year, the women have charge of incense and candles, the burning of paper clothes, or launching paper boats and lanterns across the waters of the bay. The men are made guardians of the shrines, which will determine their luck for the entire year, and the one custodian is determined by casting lots. Two wooden objects, one flat, the other rounded on one side, are dropped over the side by each contestant. If both land the same way, the luck will be phenomenal, but if a round and a flat side bob on the surface, their luck will be canceled out. Each man is permitted ten tries while he kneels in prayer before the divinity, and the one with the greatest number of good-luck tosses keeps the shrine in his cabin for the entire year. But he must be up at dawn to burn incense before it; if he oversleeps, the shrine is taken from his custody.

It is interesting to note that the Chinese word for *fish* and *abundance* is the same—*yu*. The South China Sea has always provided ample sea life, which is a staple of the *Shui-jen*'s diet; its reproductive effects are considered magical, so it has become a symbol of regeneration. Also, it is thought that the fish is completely content in its marine world, so the fish, or *yu*, is the epitome of marital happiness. Furthermore, it is the talisman to avert evil, and is one of the eight basic symbols of Buddhism.

The *Shui-jen*'s ship is his floating domain. It is the cradle of his family, his working vessel at sea, and his entire world. His control is absolute. He keeps a firm hand on the tiller and knows every caprice of the sea. The *Shui-jen* culture is slowly vanishing, but it will be a reluctant effacement because the water people are resistant to change. They are the proud outcasts.

# The Bull-horn Acacia

# Mexican symbionts offer new study area

### By Virgil N. Argo

When the conquistadors described the remarkable plants encountered in the Western Hemisphere their fervor was justifiable; in deserts, on high mountains, and in humid jungles, they had seen large and spectacular forms unknown to Europeans. Many of the striking new plants were carried back to Europe by the botanists who followed close upon the heels of the military men. (The cacti that today grow in such abundance and variety of species around the Mediterranean stand as testimonials to the zeal of the early plant collectors in the New World.) In the year 1570, Francisco Hernandez, a court physician, was sent out by Philip II of Spain to what is now Mexico to investigate the natural resources of New Spain. In a report of his findings, written in 1575, he described, among other things, a shrub or small tree he had observed in coastal northeastern Mexico, near what is now Tampico. It is a species of acacia that possesses a pair of extraordinarily large stipular thorns at the base of each of the bipinnate leaves, and which has, as a result, been commonly called bull-horn acacia. The hollow thorns serve as nests for colonies of ants, which swarm out pugnaciously to repel any human or other animal that touches the plant. This defense of their domain is highly efficient, since each of the multitude of current and previous years' thorns on the plant is inhabited. The insects possess fiery stings and are fleet of foot, nervous, and belligerent. Hernandez made a woodcut of the plant's leaves and thorns to illustrate his report, describing the plant so well that today the species from this region has been named *Acacia hernandezii.*

**Six-foot plant** of *A. sphaerocephala* grows near Pan-American Highway in Mexico. Close-up of same plant, *left,* shows ant-cut holes in thorns.

Most of the many species of the genus *Acacia*—450 in all—produce legumes, the seed pods so characteristic of the family Leguminosae. At maturity, these pods split open along one or both of two sutures. The Mexican ant acacias discussed here do not split in the regular fashion; instead, the seeds are liberated only when the seed capsules dry out and open irregularly. The flowers are minute and clustered together to form spherical heads or cylindrical spikes of what appear to be nothing but stamens, although the individual florets actually have the full complement of five tiny petals and much-reduced calyx lobes. The associated ants belong to the genus *Pseudomyrma.* Biologists of the nineteenth century were most interested in these myrmecophilous plants, and a number of species have been described from Mexico and Central America. In 1872, Thomas Belt, in his widely read *The Naturalist in Nicaragua,* described in detail the extrafloral nectaries on the petiole and rachis of the acacia leaf. He also described the small, orange-yellow, elliptical bodies attached to the tips of the young leaflets, which possess no photosynthetic function, but are rich in potential ant food and are harvested and used by ants along with the nectar available. These food bodies have been named "beltian bodies" in honor of their describer.

Belt conducted experiments that indicated a symbiotic relationship of a highly beneficial nature existed between the plant and the insect. The ants receive food from the host plant in addition to protective housing in the large, tough, hollow thorns, which sometimes have a spread of as much as five inches and a cavity diameter of a half-inch. Belt's experiments showed that leaf-cutter ants and goats defoliate acacias that have no *Pseudomyrma* species living in the thorns, but leave untouched those that possess the normal population of symbionts. These ants may protect the host plant from the ravages of cattle and goats, but thorns alone seem to have played an efficient role as survival mechanisms against grazing animals in desert regions, and the ant acacias have an astonishing abundance of thorns. As a result, it is difficult to arrive at a real evaluation of the ants' portion of the whole defensive setup.

Observers have commonly mentioned the severity of the toxin injected by the ant's sting, reporting that it left painful swellings that persisted for as much as twenty-four hours. From my own experience I can testify that the stings are truly hot at the moment of contact, but the pain has never lasted longer than a few minutes and there was no swelling. Other people, however, may have different degrees of sensitivity. The ants were able to climb onto my hands and arms before I could avoid them, but they ran about rapidly for a moment or so

before humping up their backs in preparation for real offense—a period of grace that enabled me to brush off many potential punctures. It is not possible to avoid all stings if one approaches a plant for close observation, photography, or for purposes of collection, but possibly painful results are ordinarily not serious enough to be a very strong deterrent.

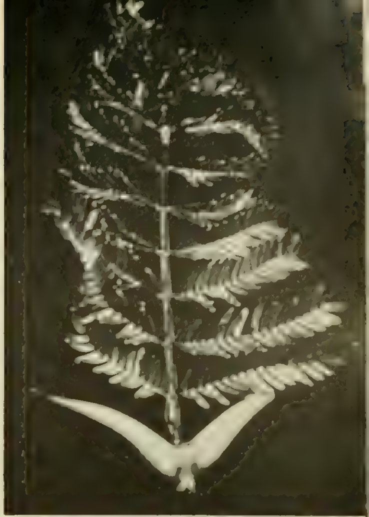
One of my first lines of speculation about the ant—plant relationship was whether or not the ants might render the plant a service as pollinating agents. I had never seen the plants in bloom, so I bore this possibility in mind on two recent trips into Mexico. The first of these—of only a few days duration—was made during the middle of May, 1963. The acacia plants were found growing abundantly along the Pan-American Highway between Ciudad Victoria and Ciudad Mante, a few miles south of the Tropic of Cancer, where I had first seen the plants in 1946. But no live flowers were present in any stage, apparently the result of a wave of cold weather the previous winter. The species here was *Acacia sphaerocephala.* Although there were numerous ants hustling about over a new growth of twigs, with leaves and thorns, that had just recently sprouted after the first early rains, ants were not observed to be feeding at nectaries, and they ignored the beltian bodies on the leaflets *(photograph, page 25, top)*. Normally these are found and nipped off as fast as the young leaflets unfold, but in this case they remained in place until the leaflets were of full size, and the normally bright orange-yellow bodies had become grayish. The second item of interest was that all the ants we watched were wingless and became engaged sooner or later in gnawing holes in the hollow thorns, which were fairly tender at this early stage in comparison to their tough, hard texture at maturity. A single hole was made in one or the other of each pair of thorns, and this served as an entrance to the common cavity of both thorns. After the hole was finished, the ant that made it went away, apparently in search of new thorns to open up. This work of hole gnawing seemed to be the sole activity of all the ants in evidence, although some individuals were seen to be giving what appeared to be a critical inspection of completed or partially completed holes. This may be an extreme case of anthropomorphic thinking, but one cannot help wondering how the

**New holes**, *left*, have been bored by scout ants before the colony swarms.

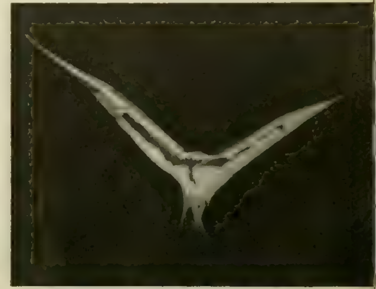
ole cutters are "appointed" and if hese seeming inspectors are actually supervisors" of some sort.

When split open, the young thorns vere found to be empty, and in none f them was there any pulp, sweet or therwise, as has been reported. On he other hand, when thorns of preious years' growths were opened, hey were found to be crowded with nts, pupae, and larvae. In addition, nany of the adults were winged, which ndicated a preparation for swarming o new quarters. This seems to indicate hat the "gnawers" prepared entrance oles in new thorns that would, when the colony swarmed, become homes or the new colonies. Certain aspects f this behavior present an interesting parallel with the behavior of honeybees just previous to swarming. Beekeepers have always observed that swarming preparations interrupt the normal colony activities of gathering nectar and pollen. A few days before the departure of a swarm, individual bees fly about in a special way, ignoring flowers but acting for all the world as if they were looking for a suitable home for the swarm that was due to issue from the old hive. Whether right or wrong in their interpretation, the beekeepers call these inquisitive prowlers "scout bees," and in some way, they are supposed to transmit information concerning a suitable home location for the new swarm. Unfortunately it was impossible for me to stay and observe the swarming habits of the acacia ants, and so far, I have found no accounts of this life phase in available scientific literature.

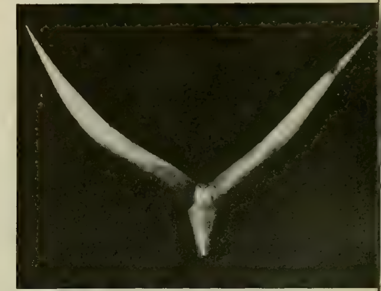
When I returned to Mexico in June of 1964 I found that the swarming season was apparently over, and all of the new thorns were occupied. Ants were busy harvesting the beltian bodies as rapidly as the new leaflets unfolded. but there were no flower heads on the plants of *A. sphaerocephala*, again apparently the result of winter damage. We drove out from Ciudad Mante to Tampico and once more I was disappointed, since the abundant plants along the way showed no new growth and there was every evidence of a delay in the beginning of the season of rains. But when I came back to the Pan-American Highway from Tampico to Valles I traveled through a region where rains had started and the farmers were busy preparing to plant their crops. Along the road were found an abundance of growth and blossoms on the acacias, apparently *A. hernandezii*. All thorns were inhabited except for those on new plants recently grown up from roots of certain old plants that had been cut down by surveyors working along the highway. The new plants apparently had not been visited by any ants, since no old nest thorns were present from a previous year's growth. This lack of ants in new plants that had grown from the roots of old, cut plants was observed in other places along the Pan-American Highway. It would appear that the entrance-hole cutters and the new swarms had not been able to effect colonization of the new plants.



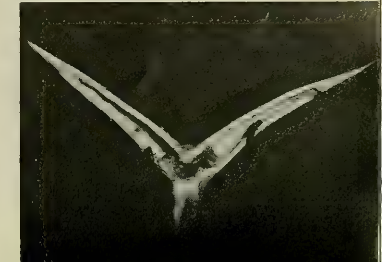
**Beltian bodies** can be seen on edges of leaflets of current year's growth.



**New thorns** have the entrance holes, but are not yet occupied by ants.



**Old thorns**, *above*, were occupied by an organized ant colony, *below*.



How readily the ants will walk on the ground to reach new acacia plants was not ascertained. But new, ant-free, second-growth plants were discovered only a few feet removed from old, first-growth, ant-inhabited plants. This would indicate the failure of wingless ants to travel this short distance overland to gnaw the entrance holes necessary for colonization.

Another ant acacia, which I considered to be *Acacia cornigera,* was found growing abundantly in locations along the highway between Valles and Tamazunchale. Here again, as in the case of the plants near Tampico, the acacias were in abundant bloom, and in both cases there were plenty of insect pollinators at work. The cylindrical flower spikes on both *A. hernandezii* and *A. cornigera* are as large as 1½ inches in length and ⅜ inch in diameter. When the minute flowers are open, the whole spike takes on a bright golden-yellow color from the closely packed, pollen-laden anthers. Ants in abundance could be seen walking about over the pollen-covered surfaces of the flower heads, but exactly what was being accomplished was obscure. It was apparent, however, that even such random travel must have distributed pollen from floret to floret. In addition to the ants, there were numerous other insect visitors to the flowers. Solitary bees, honeybees, and flies were most abundant, and there were occasional small beetles and hymenopterons as well. There was little evidence to indicate that any of these insects gathered nectar, but certainly the solitary bees were engaged in collecting pollen, as the solid coatings adhering to the hairs on the undersurface of their abdomens testified. There was no evidence whatever that the ants "resented" the other insect visitors or even paid any attention to them.

**Flower head** of *A. cornigera* is at top of twig; older cluster is just below.

But when one searched for fruit formation as evidence of successful pollination, the picture became confused. A succession of flowering heads was maturing, and apparently the blooming season is a long drawn-out one. It was well under way by the middle of June when the first observations were made on *A. hernandezii* and *A. cornigera,* and when the plants were visited a month later there was still abundant bloom and a great number of new flower heads were forming. But during this period only a very few heads were found on which individual florets were developing fruits. Among the related genera of the Leguminosae that develop such heads or spikes of small florets, the number of seed pods produced by one flower head is relatively very small, but ordinarily there will be from one to five fruits from each spike.

In these acacias the number of heads that produced any fruits at all was extremely small. There was a scarcity of plants showing remains of the persistent fruits of previous years, which gave evidence that this present barrenness was not simply the result of a bad season. Furthermore, most of the intact fruits were seen to contain exit holes of some insect larvae that had hatched from eggs deposited in the very young plant ovaries. Examination showed that all seeds had been destroyed. Certainly this first study would indicate that pollination of flowers is not too important a factor in the survival of the acacia species if seed production is an important measure of survival success. The abundance of other insect visitors to the acacia flowers would indicate that the ants do not play any special or important pollination role.

My hope is to spend a whole growing season, at least, to work out the details of this rather confusing cycle of plant and insect relationship. There are a number of points that are far from being clear and logical. Of course, one must realize that the ecological factors that govern plant activity below the Tropic of Cancer are different in many respects from those that function to the north of it, and to the northerner there will seem to be many contradictions of what he considers normal behavior. The orderly succession of the seasons—spring, summer, autumn, and winter—is not as important in the tropics as in the temperate zone; the most important factor is the available rainfall. In Mexico, rain normally occurs in the afternoons during the months of June through October. It results from thermal updrafts that carry warm, moisture-laden air off the Gulf of Mexico up to the cold, high altitudes where cumulus clouds are formed. The moisture precipitates in the form of rain, the amount of which varies according to the strength and direction of the air currents from the sea. The rain may even cease for certain periods. These interruptions in the normal annual cycle of plant growth may cause what would seem to be gross irregularities. More studies of the ecology of the region, together with more taxonomic studies, could probably uncover a more logical set of responses to the natural environmental factors. Possibly the ant–acacia interrelationship is more mutually beneficial, let us say, than it would appear at first study.

The four species of ant acacias discussed were never found above an elevation of about 500 feet. I have observed them in the states of Tamaulipas, San Luis Potosi, Guerrero, and Yucatan, but never north of the Tropic of Cancer. This coming summer I plan to become acquainted with as many as possible of the species to be found in the region that lies between Oaxaca and the border of Guatemala.

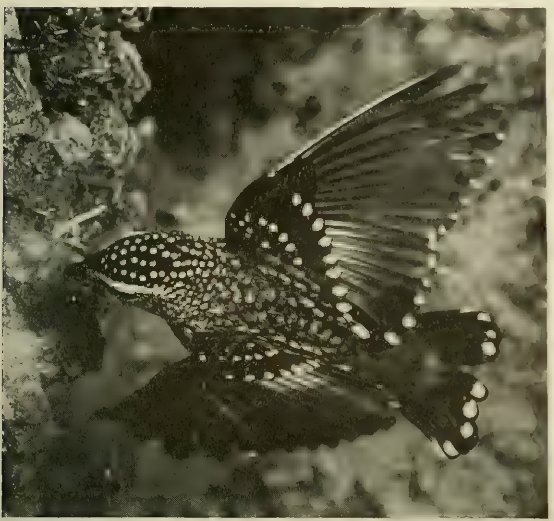
**White** beltian bodies persist on o
leaves; yellow ones are on new growt

# Australia's

# Spotted Diamondbirds

by ALLEN KEAST

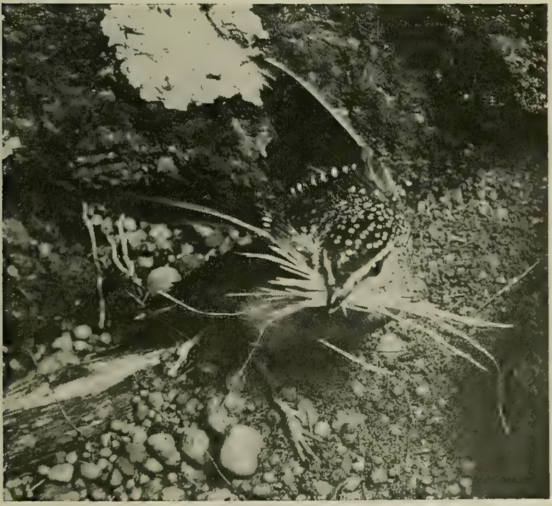
photographs by
MICHAEL K. MORCOMBE



*Beautiful markings from which this Spotted Diamondbird derives its common name are seen as bird—a male—flies to its burrow.*

*Male, its yellow throat barely visible, lights on tea tree, left, on way to burrow, which is in a bare bank to permit quick egress.*

*Outside her burrow the female, below, who is less colorful than the male, collects billful of grasses to add to her growing nest.*

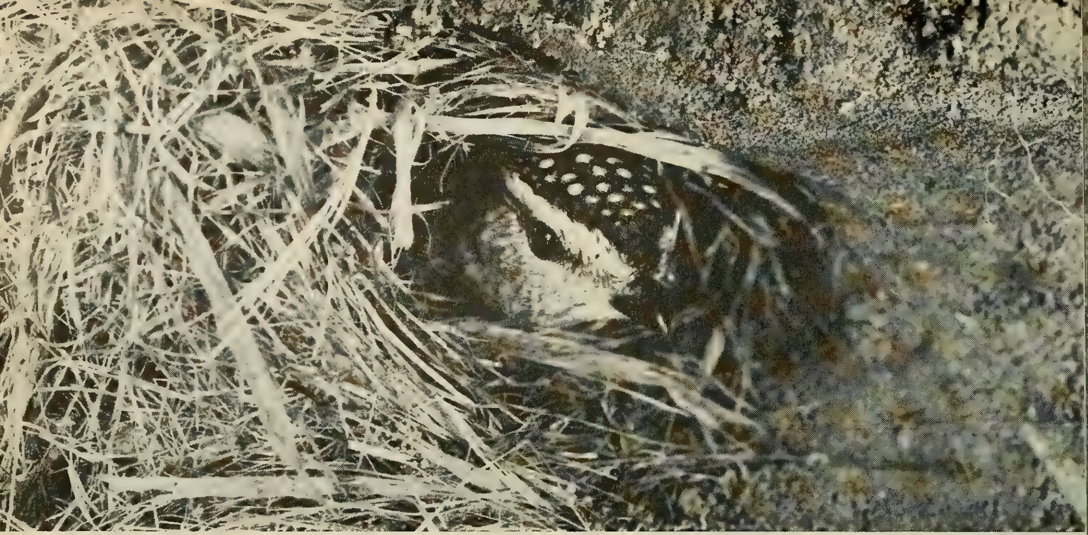


ONE of the interesting novelties of the Australian avifauna are the Diamondbirds, or Pardalotes (*Pardalotus*). The popular name comes from the clear white spots that adorn the feathers. Diamondbirds are about the size of the American Kinglet or European Goldcrest–body length 3¼ to 3½ inches–and are hence among the smallest of birds. They live high in the pendent foliage of the eucalypts, or gum trees, each leaf of which is about the size of the bird itself, where they search for scale insects, tiny spiders, beetles, and other life.

Few people would be aware of the existence of the Diamondbirds were it not for their melodious, piping call notes, uttered singly, as a pair, or in a sequence of four that come echoing down from the treetops like rich little bells. Since the density of the birds is at the rate of one to every several large trees, and the calls carry a great distance, their song is one of the real joys of spring mornings in the Australian bush.

Diamondbirds are common where there are eucalypts, including the suburbs of the large cities. It takes the trained eye of an ornithologist, aided by field glasses, to see them while they are pursuing their daily activities high in their leafy world. But in the springtime the Diamondbirds come to ground. The nesting site of the commonest species, the Spotted Diamondbird featured in this article, is a tunnel in a bank. Any slight irregularity in the ground might be used–the cutting beside a garden path, a mound of soil raked up by a gardener, the soil among the roots of an overturned tree in the forest, a slope, or a depression in the ground a foot or so deep–anywhere, in fact, where the soil permits the driving of a horizontal tunnel.

The Diamondbirds are quite fearless. As one walks through the forest or along a path, the bird will burst out of its burrow almost at one's feet, alight in a shrub a few feet away, and sway from side to side with a curious bobbing motion. If the observer remains still for a minute or so the bird will drop back down to the tunnel, hover before



# Tiny bird constructs nest in bank tunnels

it momentarily like a butterfly, then alight and recommence its excavations, sending showers of sand into the air behind it.

At the end of the tunnel, which is 18 to 24 inches deep when completed, the bird excavates a chamber and there builds a domed nest of fine strips and shreds of bark intermingled with dried grasses, with an entrance at the side. Four or five rounded, pearly-white eggs are laid.

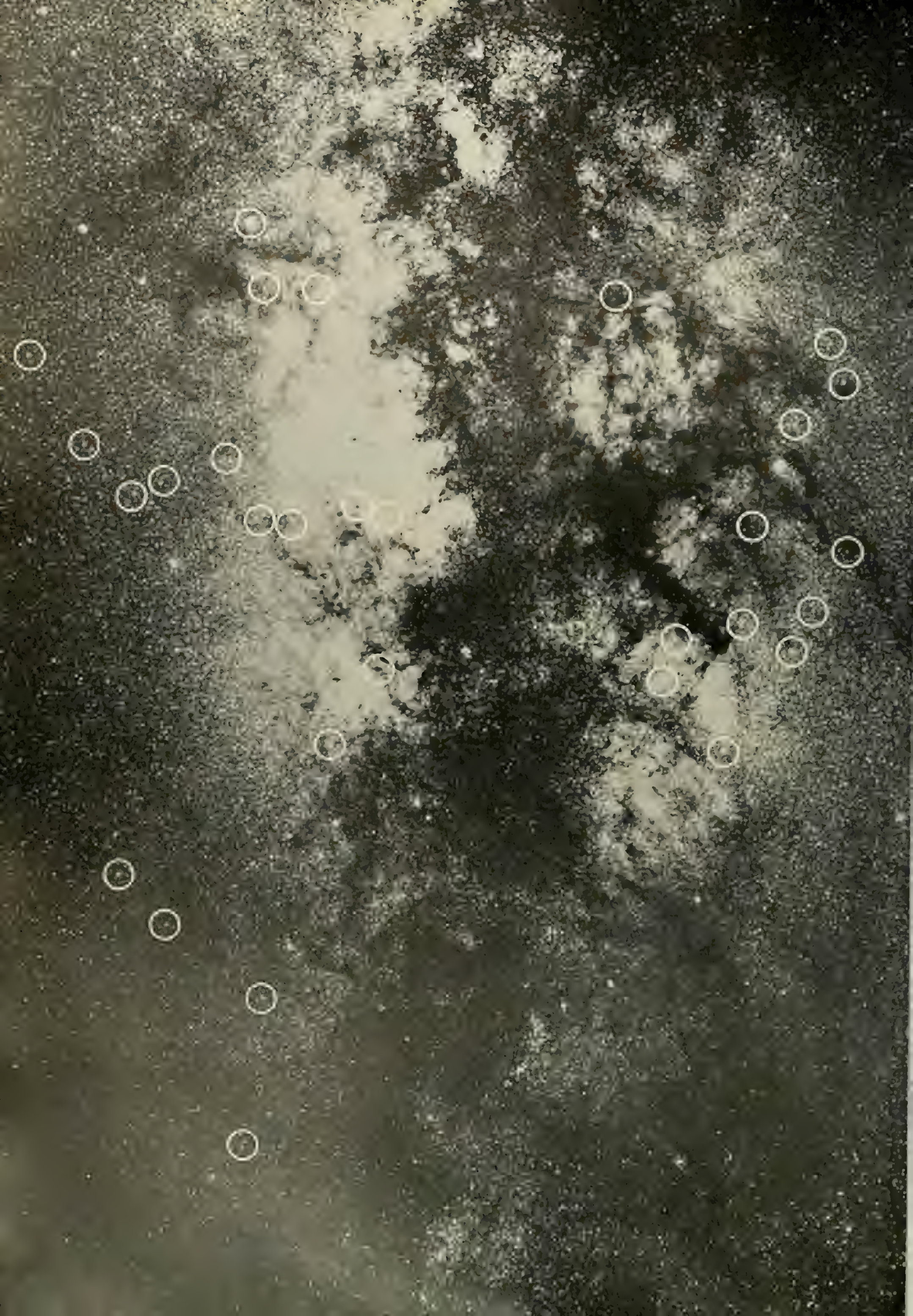
PARDALOTES are confined to Australia. There are seven species, each inhabiting a slightly different vegetation formation or area of the continent. There are two in the forests of eastern Australia and in the Southwest where these photographs were taken. Five of the seven species use hollows in trees as their nesting sites. Doubtless the tunnel of the Spotted Diamondbird involves more risks than a hollow limb (small lizards, for example, have been observed eating the eggs), but here the birds do not have to compete with Tree Swallows and with the introduced Starling for suitable nest sites!

The group belongs to the Dicaeidae, a family with a wide range in the oriental region, generally known as "flowerpeckers" from the nectar-feeding habit of many species. However, mistletoe berries are also prominent in the diet of a number of them, and in places the birds are an important agent in spreading this pest. Not so the Pardalotes of Australia; these beautiful small birds are completely insectivorous.

*Young birds at right are old enough to come to mouth of the burrow to be fed by the male, who clings to opening.*

*hotograph of this incubating emale, left, was made by a areful opening of nest only very few inches at a time.*

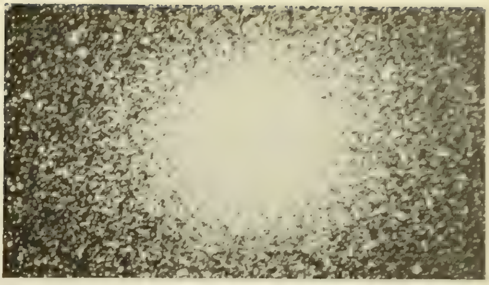
*Again, great care was taken to protect these young on the bark and grass nest some 18 inches inside the soil bank.*



# SKY REPORTER

## Globular Cluster in Hercules occupies vast volume of space

By Thomas D. Nicholson



**Close-up view** of Hercules cluster through 200-inch lens.

In 1714, the great English astronomer Edmund Halley discovered a small region of brightness in the constellation Hercules. He described the object as "a little patch . . . but a few minutes in diameter." Observing, however, that it was clearly located among the fixed stars, he went on to say that the patch "cannot fail to occupy spaces immensely great, and perhaps not less than our whole solar system." The object that Halley observed is known today as the Globular Cluster in Hercules, and it indeed occupies spaces immensely great, although Halley's standards of greatness are no longer adequate to describe it. This cluster of stars is the object selected by astronomers at The American Museum-Hayden Planetarium as the fifth of the Seven Wonders of the Universe.

The Globular Cluster is a spherically shaped cloud of perhaps half a million stars, packed so densely together that they appear, toward the center, as just a ball of light. Individual stellar members of the cluster can be recognized only in the outer regions, where they are somewhat more separated than in the center. The solar system we know today is much more vast than the one Halley knew, for to him it extended out only to Saturn, a distance of about 1,800 million miles across. Based on the orbit of Pluto, the farthest planet known, we can now judge the distance across the solar system to be about 7,400 million miles, or about four times greater than Halley believed. Even so, the Globular Cluster in Hercules, which is estimated now to be about 170 light-years across, occupies a volume of space equal to about 2,500 billion times the space occupied by our solar system.

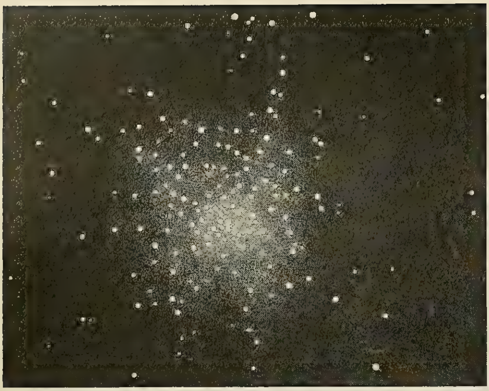
The Cluster is one of about a hundred similar objects known in the stars of our sky. It is among the largest and brightest members of this unusual class of celestial objects, and the only one that can be seen with the unaided eye by observers in the Northern Hemisphere. It appears as a faint cloud of light between the bright stars Eta Herculis (magnitude 3.5) and Zeta Herculis (magnitude 2.8), about one-third the distance from Eta to Zeta. The integrated magnitude of the cluster is 4.0, which places it above the threshold of naked-eye observations. But since it is an extended object rather than a single point-source (as a star), it is more difficult to see than a star of similar magnitude. Nevertheless, it can be picked up visually on a clear dark night, if its location is known. From about 2:00 A.M. on during the nights of January, the constellation Hercules is high enough in the northeastern sky for the cluster to be found.

**Circles indicate more than one-third of all known globular clusters in this small-scale photograph of the constellation Sagittarius, located in southern region of the Milky Way.**

In a small telescope, or even binoculars, the cluster can be seen easily as a round, luminous area about one-third the diameter of the full moon. Larger telescopes are required to see the individual stars of the cluster. The French astronomer-artist Leopold Trouvelot used a 15-inch telescope to make his 1874 drawing of the cluster, which appears on page 34. Telescopes of this and larger size show thousands of stars in the cluster and reveal what appear to be strings of stars and dark lanes in the cloud. They also show that the cluster is not perfectly spherical in form, but slightly flattened. The full richness of the cluster is seen best, however, on long-exposure photographs made with large telescopes. In such photographs, as many as 43,000 individual stars have been counted in the outer regions of the cluster, which has been seen to have an angular diameter of about 23 minutes in arc, or more than two-thirds the diameter of the full moon.

Astronomers recognize two distinct types of clusters among the stars. One type is known as an open, or galactic, cluster—a loose organization of several dozen to several hundred stars that have a common motion in space and share other properties as well. More than 500 such clusters have been identified, and several thousand more probably exist in our sky. The stars of the second type—the globular cluster—are much more compactly arranged and far more numerous, ranging from tens of thousands to perhaps a million in the very largest. The average star population in globular clusters is about 100,000. The catalogue of Helen S. Hogg, published in 1959, lists 118 objects identified as globular clusters, and there may be several hundred more as yet undiscovered.

Another important difference between the galactic clusters and the globular clusters is their distribution. The galactic clusters are found concentrated along a rather narrow belt of the sky corresponding to the circular band of brightness called the Milky Way. The vast majority of these star groups are found within a few degrees of the center line of the Milky Way, but they extend rather uniformly around the sky along this belt. The globular clusters, on the other hand, are often found at some distances from the plane of the Milky Way, but are highly concentrated around the region of the Milky Way in the constellation Sagittarius, which is prominent in the southern sky on summer nights. Indeed, in small-scale photographs of the region of Sagittarius, one can see more than one-third of all the known globular clusters (*photograph at left*). Only four



**Globular Cluster** in Hercules, *above,* was drawn in 1874 by Trouvelot who used 15-inch telescope. His accuracy is confirmed by photograph, *below,* taken through 60-inch lens.

of the known globular clusters are not found in the half of the sky around this constellation. This peculiar distribution led astronomers, during the early 1900's, to investigate the possibility that they could be used to learn the extent of the stellar system represented by the Milky Way and the position of sun and earth within the system.

The first problem was to find some means of determining the distances to the globular clusters. It was recognized that they must be some distance from earth, for with their richness of stars they were the beacons of the sky. The combined illumination of the tens of thousands of stars in a globular cluster should certainly be visible at far greater distances than any single star in the cluster. A massive attack on the problem was undertaken by Harlow Shapley, of the Harvard College Observatory. He proceeded by investigating the nature of the individual stars that comprise the clusters. He found that they contain a great many short-period variable stars of the type that are now called R. R. Lyrae stars (after a prototype star in the constellation Lyra). In addition, he found that the brightest stars in the globular clusters are red and yellow giant stars, rather than blue stars, as is the case in the solar neighborhood and in other star clusters. Indeed, the globular clusters are completely devoid of the brilliant blue stars observed in other parts of the sky.

An investigation of stars in the sun's vicinity similar to the short-period variable stars in the globular clusters showed that these cluster-type variable stars have an average absolute magnitude of about zero. By observing the average apparent magnitude of the variable stars in a cluster, therefore, Shapley learned the extent to which these stars are dimmed by the cluster's distance from the earth. Similarly, other studies had shown that the brightest red giant stars in the sun's vicinity are about two magnitudes brighter, on the average, than the cluster-type variable stars. Shapley selected the twenty-five brightest stars in each cluster as representing the average of the cluster's brightest red giant stars and again observed their apparent magnitudes. The extent to which these stars were dimmed also was an indication of the distance to the cluster.

The globular clusters are found to be arranged in a roughly spherical system with a center in the direction of the Milky Way in Sagittarius. The center of the system, according to Shapley, is at a distance of about 50,000 light-years from the earth. The results of Shapley's investigation of the distance and distribution of the globular clusters were published in 1918. Subsequent revisions of Shapley's work, allowing for the effect of absorption by interstellar gas and for corrections to the absolute magnitudes of the stars he used, place the distance to the center of globular clusters at about 30,000 light-years. Shapley's work thus provided the first clear evidence of the size of our system of stars and of the distance of the earth from its center.

To return to the object we selected as the Fifth Wonder of the Universe, the actual number of stars it contains cannot be counted, because of the crowding toward its center. But the brightness, size, and distance of the cluster would indicate that it should contain about 500,000 stars. Assuming this to be true, it is possible to estimate the density of stars in the cluster. In the sun's vicinity, the star density is about one per 300 cubic light-years. The average star density in the Globular Cluster in Hercules is about five times as great, or about five stars per 300 cubic light-years. But the stars of the cluster are packed much more densely near the center than in the outer regions. If we assume that the density in the center is about one hundred times as great as the average density throughout the cluster, there would be about five hundred stars in a volume of 300 cubic light-years, or nearly two stars per cubic light-year.

Suppose we imagine a planet revolving around one of the stars in the center of this immense cluster; what would its sky be like? At night, when its sun had set, the sky would be filled with brilliant stars, predominantly yellow and red in color. The nearest of these stars—about one light-year distant—would have an apparent magnitude of about −8, or more than one hundred times the brightness of Sirius, the brightest star we see from earth. But there would be more than 35,000 stars in its night sky, all brighter than Sirius, seen from that imaginary planet in the center of the globular cluster. The sky of the night, on such a world, would be as bright as the skies of early twilight are on the earth.

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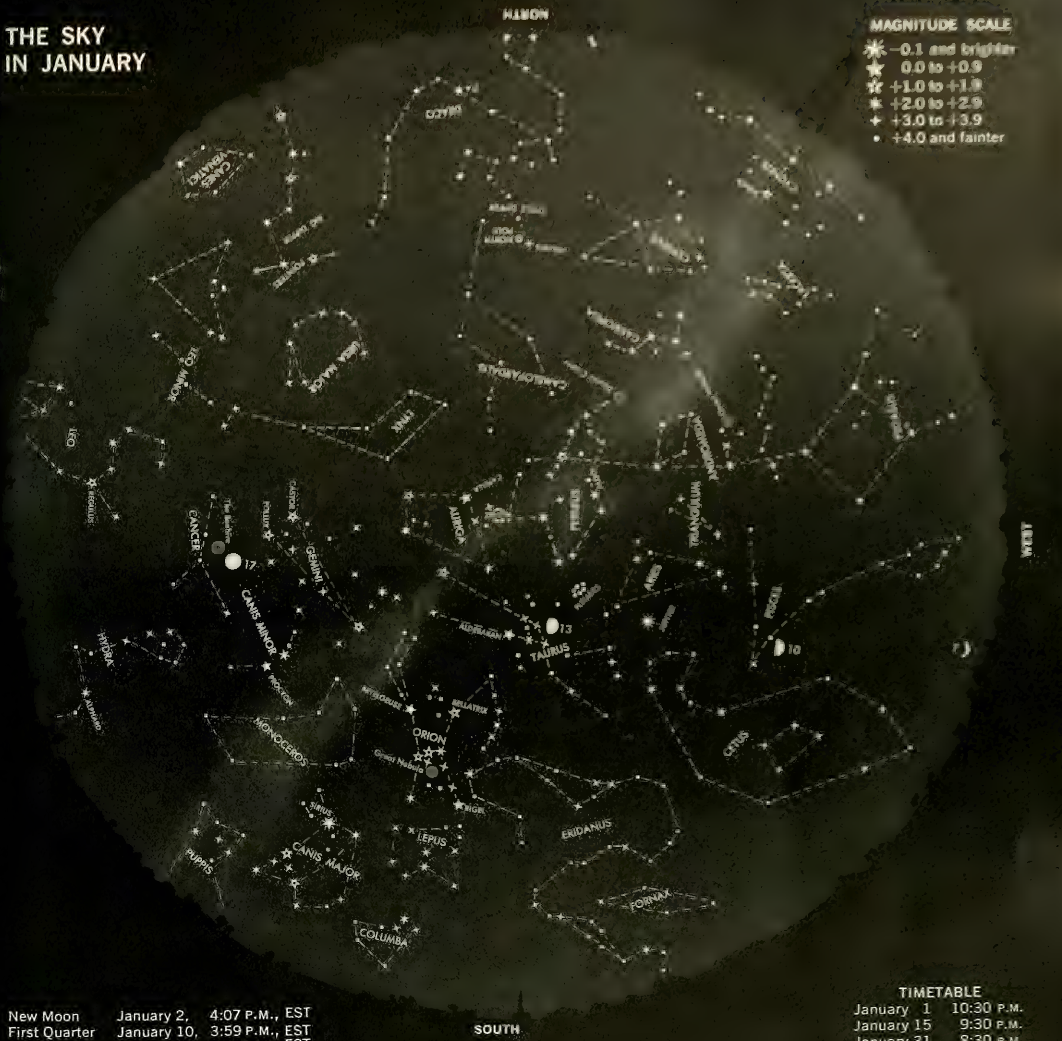
**Dr. Nicholson,** the regular author of this column, is also Chairman of The American Museum-Hayden Planetarium.

# THE SKY IN JANUARY


NORTH
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
DRACO
CANES VENATICI
URSA MINOR
LEO MINOR
URSA MAJOR
CAMELOPARDALIS
LYNX
LEO
REGULUS
CANCER
The Beehive
POLLUX
CASTOR
GEMINI
17
CANIS MINOR
PROCYON
HYDRA
ALPHARD
AURIGA
ANDROMEDA
PLEIADES
ALDEBARAN
13
TAURUS
PISCES
10
BETELGEUSE
BELLATRIX
ORION
Great Nebula
MONOCEROS
RIGEL
CETUS
SIRIUS
LEPUS
ERIDANUS
PUPPIS
CANIS MAJOR
FORNAX
COLUMBA
WEST
SOUTH

| | | |
|---|---|---|
| New Moon | January 2, | 4:07 P.M., EST |
| First Quarter | January 10, | 3:59 P.M., EST |
| Full Moon | January 17, | 8:37 A.M., EST |
| Last Quarter | January 24, | 6:07 A.M., EST |

TIMETABLE

| | |
|---|---|
| January 1 | 10:30 P.M. |
| January 15 | 9:30 P.M. |
| January 31 | 8:30 P.M. |

(Local Mean Time)

January 2: Earth is at perihelion, closest approach to the sun in its orbit. The earth is about 91,450,000 miles from the sun on this day.

January 4: Look for the Quadrantid meteor shower, radiating from an area off the end of the Big Dipper's handle, during the early hours on this date. From midnight on, the radiant is well up in the northeast. This brief shower is one of the most intense of the year, with an hourly rate of 25 to 40. The moon will not interfere.

January 7-8: The morning skies on these two days offer a good opportunity to see the elusive planet Mercury. On the 7th, Mercury is in conjunction (1.2 degrees north) with Venus, and on the 8th, Mercury is at greatest westerly elongation. Shortly after 5:30 A.M., the bright red star Antares (magnitude 0.9) is about 15 degrees above the horizon in the southeast. Venus is then rising some distance to the left of Antares, and is easily recognized by its brightness (magnitude —3.4). Mercury appears about one degree to the left and a little above Venus. It should be visible until about half an hour before sunrise, when it will be about 10 degrees above the horizon.

January 10: Jupiter is stationary in right ascension and resumes direct (eastward) motion. In Aries, south and west of the Pleiades, Jupiter is well up in the southeast at sunset and sets about midnight.

January 11: An interesting view of Jupiter's satellites can be obtained tonight by observers with small telescopes or even binoculars. All four of the bright satellites are very nearly at their greatest angular distance from Jupiter. Callisto and Europa are to the west of Jupiter, then the bright disk of Jupiter, and Io and Ganymede to the east of the planet.

January 12: Jupiter and the moon are in conjunction about noon EST. On the evening of the 11th, Jupiter is left (east) of the moon; on the 12th it is to the right.

January 24: Mercury and Venus are in conjunction for the second time this month, but this time they are much too close to the sun to be observed.

January 29: Mars is stationary in right ascension, and begins retrograde (westerly) motion.

Saturn is located in Aquarius this month. It is visible in southwest at sunset and sets approximately three hours later.

# The Building

# Blocks of the Clouds

**Fantastic** "flying saucer" cloud was photographed in state of Washington.

## Without "dirt," man could not survive

By John A. Day

MAN depends on "dirty air" for his very existence. Although this may sound odd in these days of community war against air pollution, it is a factual meteorological statement that may be appreciated by following the story of "building blocks of clouds."

In the literal sense, what we call "air" is a gas made up of a variety of gases that are continuously mixed by atmospheric motions. Some of the constituent gases are plentiful and others are very rare: 78.11 per cent by volume is contributed by molecules of nitrogen; 20.95 per cent by molecules of oxygen; 0.93 per cent by argon; and trace percentages by other noble gases (krypton and xenon), hydrogen, methane, and nitrous oxide. Regardless of where one samples the lower layers of the atmosphere—called the troposphere—these gases are found in the same relative proportions.

Air contains a few other gases that are "mavericks" in the sense that they are present in variable amounts. Carbon dioxide ($CO_2$) comprises 0.01 to 0.1 per cent depending on the amount of combustion, plant photosynthesis, and absorption and release by the ocean that takes place in a given region. Ozone, sulphur dioxide, and nitrogen dioxide are found in very small quantities. But by far the most important maverick gas consists of molecules of $H_2O$, which we call water vapor. In equatorial maritime climates, water vapor may be present in amounts ranging up to 7 per cent of the atmosphere by volume. In other terms, a cubic yard of atmosphere, if squeezed dry, might yield a few tablespoons of water molecules. In arid desert regions, in the frigid Arctic, or at high elevations at the top of the troposphere (which ranges in summer from about twelve miles above the tropics to six miles above the poles), water vapor is still present, but only in negligible amounts. These gases make up our ocean of clean, pure air —a mixture that has evolved over a time span of millions of years.

The air found at the bottom of this atmospheric ocean in which we live is not clean. It is polluted by a variety of foreign matter that comes both from natural and man-induced causes. The primary natural mechanism for introducing pollutants into the air is the friction of the wind against the earth's surface. When this occurs over the land, surfaces of rocks are slowly abraded, and further breakdown in particle size comes about by the polishing effect of small particles rolling over adjacent small particles, somewhat in the same fashion as agates are polished in a rock tumbler. The dust from this polishing is fine enough to be carried aloft by the wind, and it becomes more or less evenly distributed through the lower atmosphere. Dust storms such as those that plagued the central United States in the 1930's are dramatic examples of this mechanism at work. An aspect of considerable meteorological significance is that some of these particles are soluble in water (hygroscopic); others are wettable but not soluble (hydrophilic); and still others are water resistant (hydrophobic).

WIND friction over a water surface has the effect of generating waves. As the wind grows stronger the amplitude, or height, of the wave increases. When the wind speed rises above about 25 miles per hour, spray is pulled off the tops of the waves. Most of the spray droplets are so heavy that they fall back into the water before they evaporate. In the case of sea water, the mechanism may leave a tiny speck of salt from the smallest spray droplets, which do evaporate, and this speck of salt is subsequently carried upward in the turbulent air.

A more effective mechanism for introducing salt particles into the air is the bursting of air bubbles found in the wake of unstable waves. Masses of water from the wavetops fall back into the ocean and carry air with them. As this trapped air seeks release from the water it rises to the surface in the form of bubbles of many sizes.

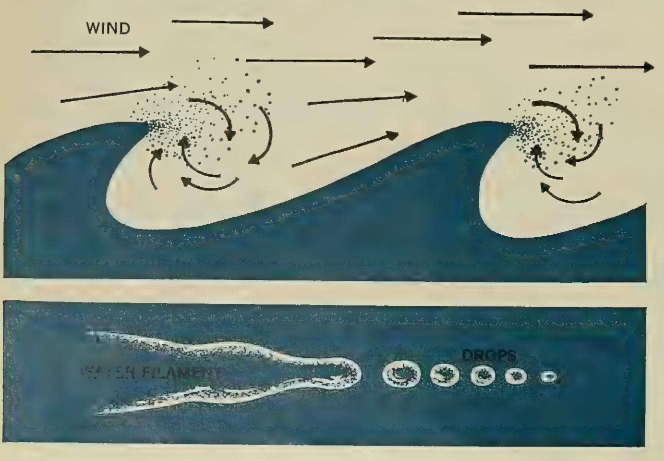
THE sequence of events that follows as an air bubble reaches the surface and bursts is very interesting to observe; it also needs much study because of its meteorological significance. I spent a year (1962-63) in the laboratories of Professor B. J. Mason, at Imperial College, London, studying this phenomenon, attempting to work out the relationship between the number of salt particles resulting from a bubble-burst and the size of the air bubble. In the illustrations at right, we see the several stages in the bursting of the air bubble. All bubbles larger than one millimeter in diameter (roughly, the size of a pinhead) depart from a spherical shape. However, at the water surface a spherical film cap protrudes. Water drains down the sides of this cap until the film reaches a critical thinness, at which point it ruptures. The burst occurs with such speed that no researcher has yet recorded it satisfactorily even with high-speed cinephotography. The ligaments of the ruptured film snap together and become very small spherical droplets that are carried several millimeters into the air. Since they are so small they evaporate rapidly and leave salt particles, each of which weighs about a million millionth of a gram. These are carried to higher elevations by turbulence. A bubble film burst is shown in the photograph on page 39.

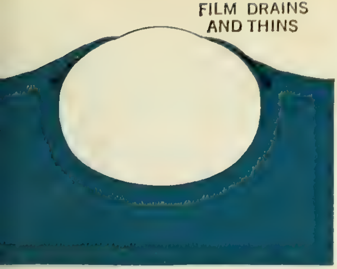
A secondary natural mechanism that operates rather infrequently, but sometimes with a massive effect, is that of volcanic eruption. When Krakatoa, in Sunda Strait, erupted in 1883, it produced a mantle of dust and ash that was noticed in the upper atmosphere of the entire Northern Hemisphere for several years afterward.

Still another natural mechanism that produces small foreign particles is the reaction of the various trace gases and water vapor under the influence of solar radiation.

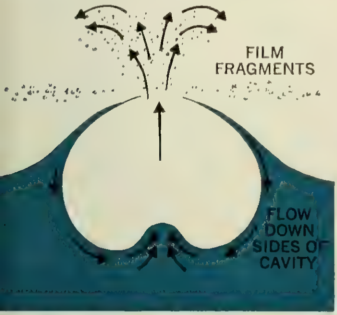
Combustion by-products pollute the atmosphere. Sometimes fires can be started by purely natural causes, as when lightning strikes in dry forest areas. More often, man creates the fires

**WAVE** near shore breaks up in torrent of tiny droplets, *above*. Spray action is shown below. Filaments of water develop necks and break into drops.

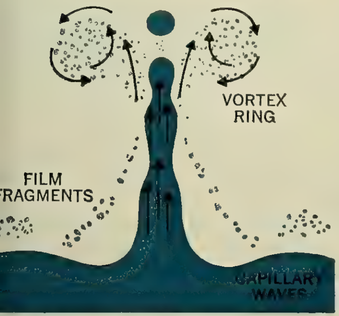




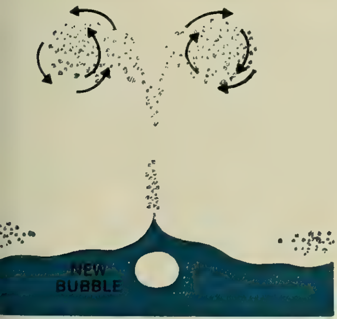
**Film cap** protrudes from surface of water in first step of bubble burst.



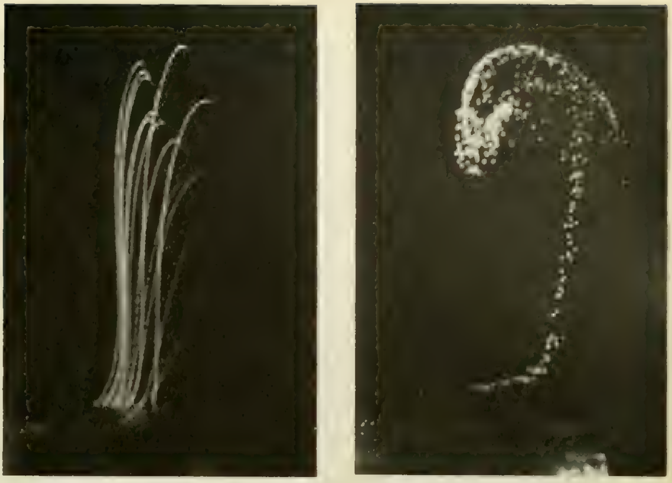
**Flow** down sides of cavity thins film, which ruptures at tremendous speed.



**Filaments** break into small spherical drops that are carried into the air.



**Tiny** salt particles remain as drops evaporate, and new bubble is formed.



Time exposure, taken in a diffusion cloud chamber in a laboratory, shows path of rising bubble film droplets, *above left;* high-speed film catches the inverted bowl effect of 300 to 400 such droplets, seen at right, *above.*

to keep himself warm, to run his factories, to propel his automobiles, and so on. The by-products of combustion are ash, soot, tar, ions, hydrocarbons, sulphates, and sulphuric acid (when the fuel contains sulphur).

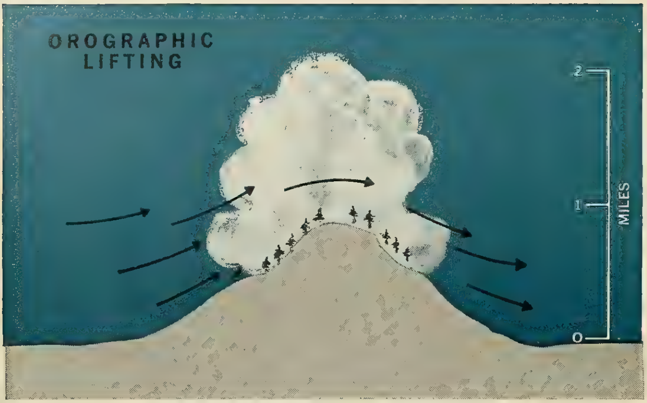
Today we have accumulated a reasonable understanding of the various kinds of air pollutant particles, particularly in the larger size range. In addition to knowing what they are and how they are produced, we know the range of concentration in which they are found. Perhaps most important of all, we are coming to understand the role they play with respect to the condensed water found in the atmosphere.

We probably would not know nearly as much as we do today were it not for a device called the cloud chamber. The first simple expansion cloud chamber was made in 1875 by M. Coulier, in France, in order to demonstrate that small foreign particles serve as centers on which condensation takes place. Air and water were enclosed in a flask. The air was made supersaturated with water vapor by compressing a hollow rubber ball connected to the flask. After the heat generated by compression was conducted away, Coulier suddenly released the ball to allow the compressed air to expand. He noted that a cloud of fine droplets was produced in the flask. Shortly thereafter (1880-81), John Aitken, an Englishman, used similar but improved apparatus to show that the cloud of fine droplets could be made more dense by introducing products of combustion, and that the cloud could be thinned by one of several procedures: by filtering through cotton wool the air introduced into the cloud chamber, by allowing the air to stand for several days before use, or by allowing it to go through repeated cycles of cloud formation in the chamber.

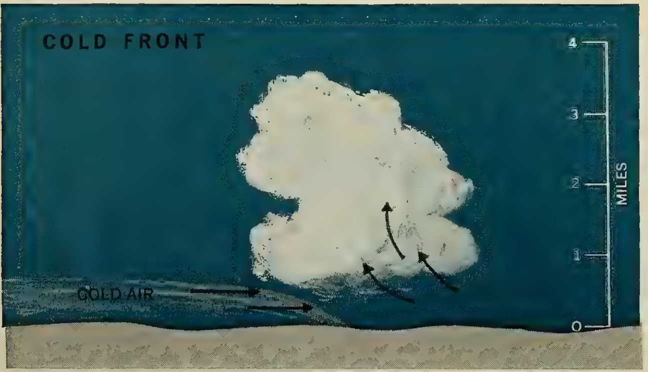
In the years following, Aitken developed various forms of an apparatus that became known as the Aitken dust-counter. With it he undertook a complete survey of the small foreign particles, or nuclei, in the atmosphere. He also showed that the thickness (more accurately, the number of particles in a unit volume) of the cloud depended on how much the air in the chamber was expanded. After taking the most careful precautions to remove all the foreign particles from the air, Aitken found it possible to produce a cloud of water droplets with a large expansion capacity. He was not sure, however, that he had removed *all* the very small foreign particles.

This uncertainty was clarified by another Englishman, C.T.R. Wilson, who, in 1895, began his famous cloud chamber experiments in the Cavendish Laboratory of Cambridge University. In Wilson's small glass cloud chamber, a given volume of air was subjected to a sudden, predetermined degree of ex-

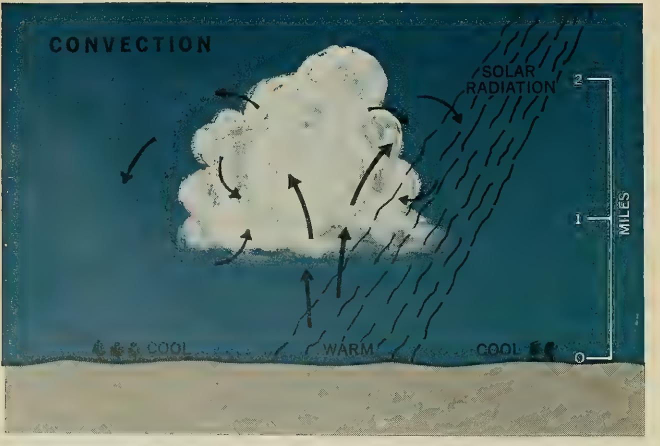
## AIR EXPANSION MECHANISMS



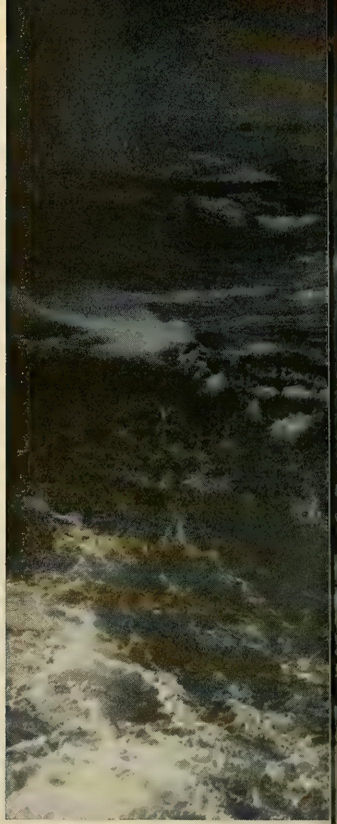
Orographic lifting is mechanism in which moving air encounters physical barrier—sometimes air itself—and flows up and over it, as seen above.



Cold Arctic air is dense and heavy, and hugs the lowest levels. Leading edge of formation acts as snowplow, forcing warmer air to rise above it.

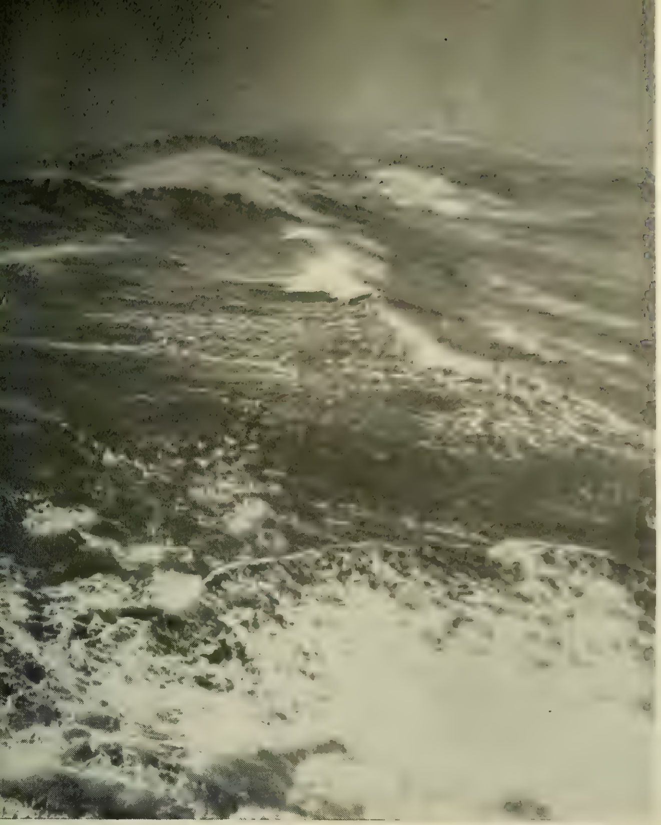


Squeezing, or convergence, of air in low levels of air stream causes it to rise. If warmed by earth, it will rise vertically because of buoyancy.



pansion. Excluding all nuclei known to Aitken, Wilson found that no visible effect was produced until the expansion ratio (the volume after expansion compared to the volume before) reached a value of about 1.25/1, corresponding to a saturation ratio (the ratio of the actual vapor pressure to that required to saturate the air at the same temperature) of 4 to 1. Greater expansions always produced about a hundred drops per cubic centimeter (roughly, the volume of a small sugar cube), regardless of attempts to filter out nuclei.

In February, 1896, Wilson used the newly discovered X-rays to irradiate the filtered air put into the chamber. This time, at the same expansion ratio of 1.25/1, a much denser cloud was produced. This suggested that the nuclei on which the droplets formed were small ions, or charged particles. Some fifteen years elapsed before Wilson succeeded in photographing these ions in the positions they occupied at the instant they were created. Such photographs are known as ion



Trapped air in unstable waves rises to the surface as bubbles of many sizes.

"tracks." This was a real breakthrough for nuclear physics, for it is this same Wilson cloud chamber that has been of such immense utility in identifying the tracks of the several kinds of nuclear particles, that is, alpha particles and beta particles (the positron and the electron).

Increasing the expansion ratio beyond 1.38/1, which corresponds to a saturation ratio of about 8 (or a supersaturation of 700 per cent), Wilson produced a cloud of very small droplets, as opposed to the smaller number of larger droplets formed on the atmospheric ions. Later theoretical work formulated by R. Becker and W. Doring (1935) bolstered the idea that droplets were produced on small groupings of water molecules, brought together momentarily by chance collisions in the highly supersaturated atmosphere of the cloud chamber.

As a result of the pioneer work of Coulier, Aitken, and Wilson, and of subsequent investigations by leaders in this field of research, there is general agreement on the following points.

1. The suspended solid and liquid particles (aerosols) vary over an enormous range of sizes.

2. Nuclei fall rather naturally into three size categories. The first group have radii between 0.5 and 200 millionths of a centimeter. These are called Aitken nuclei because they are detected in the Aitken dust-counter. The middle category ranges between 0.2 and one millionths of a meter (or ten thousandths of a centimeter). These are called large nuclei. All with radii larger than one millionth of a meter are referred to as giant nuclei.

3. The range of concentration of foreign particles is immense, from less than a few tens per cubic centimeter in mid-ocean air to more than a million per cubic centimeter in the air of an industrial city on a smoggy day.

Up to this point we have confined our remarks primarily to laboratory clouds formed inside an expansion chamber. Let us now turn our attention to the larger laboratory of the atmosphere and see how the clouds are formed under natural situations.

Most clouds (possibly excluding fog) can be thought of as comprising a dynamic system in which dirty air is made to rise. As it rises, it moves into levels of lower pressure, and then cools as a result of the expansion that takes place. The rate at which expansion occurs is dependent on the type of air motion, but is small compared to the rate of formation in a cloud chamber.

There are several mechanisms that make the air expand. The simplest and most obvious is orographic lifting, in which moving air encounters a physical barrier and flows up and over it. Sometimes air itself forms the barrier. Air that originated in the cold Arctic regions becomes very dense and heavy, and hugs the lowest levels. Sometimes there are outbreaks of this cold, dense air into lower latitudes, and the leading edge of the cold air formation acts like a snowplow, forcing any warmer, lighter air that might lie in its path to rise over it. The leading edge of such a mass of air is called a cold front. Sometimes squeezing, or convergence, of the air in the lower levels of an air stream causes a gentle ascent throughout a large volume of air. And occasionally air is locally warmed in the bottom layers through contact with the heated earth and ascends vertically because of the buoyant forces acting on it. For our purposes we will limit our discussion to this last mechanism.

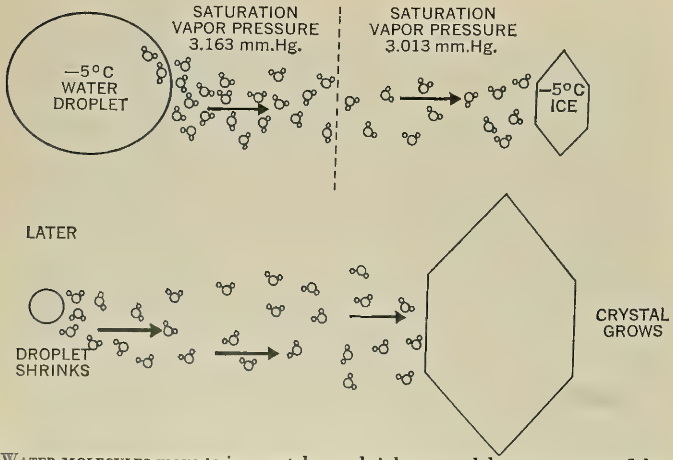
As the rising air cools, a temperature is reached at which it can hold no more moisture. The air is said to be saturated—the relative humidity is 100 per cent. What will happen when the cooling continues? If we were to extrapolate the cloud chamber results to the atmosphere for the case of perfectly clean air, the cooling would have to build up supersaturation in the air to several hundred per cent before any droplets would form. In the atmosphere it is found that the natural processes seldom need to exceed supersaturations of more than 0.1 to 0.2 per cent. There always seem to be sufficient numbers of nuclei present to give the excess water vapor enough centers on which it can collect to form tiny water droplets. However, only a fraction of the total population of atmospheric dirt acts as condensation centers. Thus we use the term "cloud nuclei" for the nuclei that become active at the saturations found in the atmosphere.

The droplet growth rate depends on several factors. Molecules of $H_2O$ must diffuse from the air onto the droplet surface, and the rate at which this occurs is limited by the rate at which the heat released by condensation can be removed from the growing droplet. Calculations made by A. C. Best (1951) of the rate at which droplets grow on salt nuclei of various masses at supersaturations of 0.05 per cent showed that it took some 40,000 seconds for a drop with an initial radius of 0.75 microns to grow to 40 microns in radius—an average maximum drop-size found within a large cumulus cloud. This is a very long time.

In the atmosphere there will be nuclei of different sizes. One assumes that condensation sets in first on the larger hygroscopic nuclei. If they are present only in concentrations of a few tens per cubic centimeter and are unable to assimilate the water vapor as fast as it is released by the rising and cooling air, the supersaturation will increase and activate the smaller nuclei. If the $H_2O$ molecules diffuse to the many condensation centers more rapidly than they are made available by the cooling of the air, the supersaturation will drop and the smallest droplets will start to evaporate. This leads us to the cloud physicist's lament: "To precipitate or not to precipitate? That is the question." Surely there must be other factors at work beyond growth by diffusion—a method which takes too long to be effective in building up a raindrop from a cloud droplet.

A major advance in cloud study was presented by the Swedish meteorologist Tor Bergeron. In a paper entitled "On the Physics of Clouds and Precipitation," to be found in the *Proceedings of the 5th Assembly* (1935) of the International Union of Geodesy and Geophysics, he proposed an explanation for precipitation from cold clouds —that is, clouds whose tops reach above the freezing level. The tops of such clouds consist of a mixture of ice crystals and supercooled water droplets. It happens that nature is so arranged that the saturation vapor pressure over a flat ice surface is slightly, but significantly, less than the saturation vapor pressure over a flat water surface, at the same temperature. (Saturation vapor pressure is the pressure at which the number of molecules leaving the solid surface is equal to the number entering it from the air.) This basic physical fact means that water molecules migrate from the droplets (which then shrink) to the ice crystals (which grow) as is seen below. In due course the ice crystal, now a snowflake, becomes heavy enough to start to fall through the cloud. On the way down it picks up other small, supercooled water drops, which freeze on contact. When it falls below the freezing level it melts and hits the ground as a raindrop.

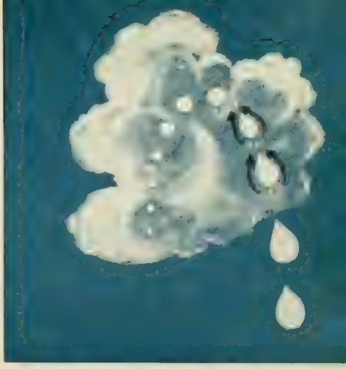
Some clouds do not reach the freezing level, yet are observed to precipitate. To explain this, cloud physicists have suggested a second mechanism—the coalescence theory. In a cloud in which there are both large and small droplets, the larger ones will fall faster than the smaller, and in the course of their relative motion there will be some collisions and many near collisions. Some small droplets will bounce off a large droplet. Others, however, will become a part of the large one—that is, two will coalesce. Thus the large droplet becomes still larger, and in time it may become large enough to fall as a raindrop. This is shown schematically at the right.


SATURATION VAPOR PRESSURE 3.163 mm.Hg.
SATURATION VAPOR PRESSURE 3.013 mm.Hg.
−5°C WATER DROPLET
−5°C ICE
LATER
DROPLET SHRINKS
CRYSTAL GROWS

**Water molecules move to ice crystals from supercooled droplets. As droplet shrinks, crystal becomes a snowflake, heavy enough to fall through the cloud.**

Enough evidence has been gathered to validate both these theories. The rub comes when a forecaster is asked to predict whether a particular cloud will or will not drop out any moisture. If (and here are some very big *ifs*) there were an accurate nuclei measurement giving number and kind; if the water vapor content of the air were accurately known; if the factors controlling general ascent or descent of the air were properly analyzed; and if the input of solar energy at the ground were known for that particular occasion there might be some hope of making an accurate statement of the likelihood of precipitation from any one cloud. At the present time, unfortunately, our measuring tools are too crude and too few to yield the quality and quantity of information needed for individualized cloud forecasts.

This brings us back to a consideration of the statement with which this article began: man depends on "dirty air" for his very existence. Perhaps the logic behind this statement is now clearer. A fraction of the dirt makes up the building blocks of clouds. Without dirt there would be no clouds. Without clouds, there would be no precipitation, and without rain and snow to water the land there would be no men to make such dogmatic statements.



Coalescence makes droplets, *above*, grow into raindrop that is of large enough size to fall through a warm cumulus cloud like the one *below*.

# Patterns in Wood

## VENEERS PRODUCE WIDE SPECTRUM OF DESIGN

### By Paul Villiard

Veneers are thin sheets of rare, highly figured woods that are glued to the surfaces of baser woods to produce panels used in the manufacture of fine furniture. For some reason, many people believe that veneered furniture is cheaper than furniture made of "honest" lumber. Actually, the reverse is true. Veneered furniture is about the only type that will withstand the steam heat, moisture addition, and air-conditioning of modern homes.

A tree with a grain suitable for face veneer is not common, and many logs must be cut to discover one. The usual method is to saw the tree open down the middle to examine the inside wood. When a veneer grain is found, the tree is squared into flitches—a word that is used for the completed bundle of veneer as well as for the rough billets from which veneers are cut.

Soft woods, burls, and crotches are sliced to a thickness of one twenty-eighth of an inch, which is standard for such cabinet veneers. First the logs are softened by being boiled or steamed for many hours, and then clamped to a massive carriage in a slicing machine. The carriage moves the log in a vertical plane against the slicing knife, which is stationary and held in a rigid indexing device that can be adjusted for different thicknesses. After each pass of the carriage, the index moves the knife forward to the exact thickness desired.

As each sheet of veneer is separated from the log, it is numbered in the order in which it was cut and stacked on top of the previous slice. When the entire flitch has been sliced, the individual sheets of veneer are passed through heated rollers to dry and are carefully stacked in the precise order of slicing. The entire flitch is then bound with steel banding or crated for storage or shipment to the dealer.

Extremely hard woods such as ebony, bubinga, and others cannot be softened successfully, and are generally sawed to one-twentieth of an inch. This is wasteful, because of the wood loss that is necessarily an adjunct to the saw cut. Also, this method makes it difficult to match adjacent pieces of veneer, because the grains are not exactly consecutive, having been separated by the thickness of the saw.

Figured woods are sorted and priced according to various classifications. There are about twenty names assigned to the different patterns that wood grains take in veneers. For instance, there are plain stripe and ribbon stripe. Mottle stripe is a modification of ribbon stripe, in which the ribbon figure is broken by flakes of crossfire—interruptions of pattern caused by the grain reversing, waving, or changing direction. Mottle is a pattern in which the entire surface of the sheet is covered with broken waves and stripes, sometimes producing a blazing crossfire when viewed from different angles. Mahogany, maple and several other woods sometimes produce the figure called fiddleback. This is a strong, rippled, very regular, and symmetrical figure, often used for backs of string instruments. Curly-figured veneer is self-descriptive—the grain is a series of large curls and circles. There are a number of other classifications, most of which are modifications and variations of one or another of the figures already described. More complicated and ornamental patterns may also be produced by matching consecutive sheets of veneer in a number of different ways.

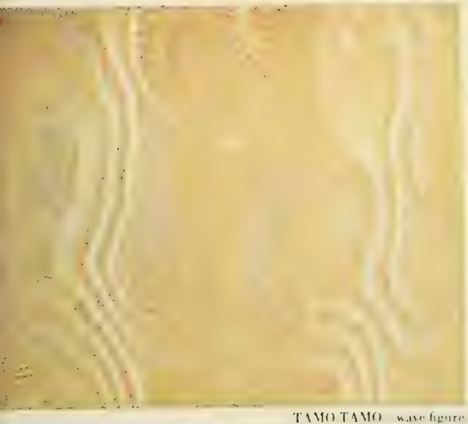
In the fancier cuts of veneer there are crotches, burls, and feathers. This last is a variation of the plain crotch—the grain produced from a cut through the log just below the junction of two main branching trunks. The figure obtained in crotch veneer is most beautiful and is in great demand for door panels, tabletops, or any place where the full beauty of the figure can be seen. In a feathered crotch, each tip of swirling grain is bent sharply downward, making an area of brilliant crossfire parallel to the main figure on both sides of center.

Burls are the familiar, ball-shaped excrescences so often seen on trees. They are the result of some sort of stimulus that has caused usually dormant buds to grow, causing a deformity. The grain inside a burl does not follow the natural pattern for that wood, but runs wild in a disordered, unpredictable manner. The half-spherical burl is mounted on a clamp and rotated against the blade at a slight angle. Since the annual rings are either greatly deformed or entirely lacking in a burl, the closely contorted grain is filled with pin or eye knots and swirls, and the resulting figure is often unusual and beautiful.

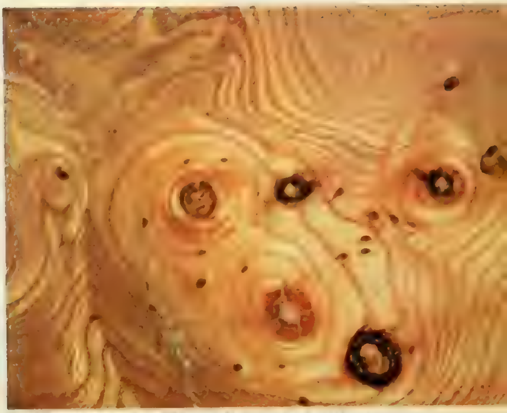
In the past, methods of gluing thin sheets of veneer to their base panels were extremely complex. Work was performed in a heated room, and it was necessary that all the clamps, glue, and the work itself be kept hot while being worked. The glues—which were generally made of animal hide—set very rapidly, so the matching, setting, and clamping had to be carried out with great speed.

This procedure was simplified, however, by the advent of modern adhesives and the development of improved clamping techniques and presses. The setting time of present-day adhesives may be adjusted by regulating the room temperature. The curing time of a panel may vary from two to three minutes in a heated press to as much as twelve hours in a cold press with a lower room temperature, even if the same glue is used. This gives the craftsman time enough to take meticulous care in preparing a panel of a particularly fine, rare veneer.

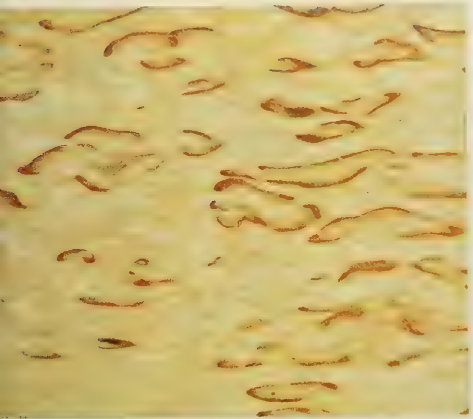
The great majority of veneers are little-known. Many have such exotic names as Tamo-tamo, Imbuya, Bethabara, Goncalo-alves, Padouk, and literally hundreds of others. They are found in every corner of the world, from the Arctic regions to the tropical jungles, and many have been used for centuries. Records and artifacts show that the Egyptians, Babylonians, Greeks, Assyrians, Romans, and other civilizations practiced the principle of lamination and overlay to embellish articles of furniture and other items.



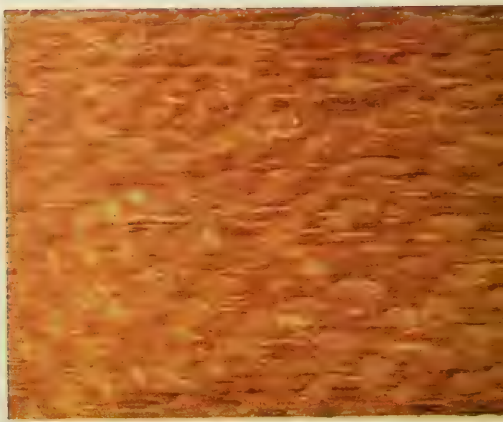
TAMO TAMO—wave figure



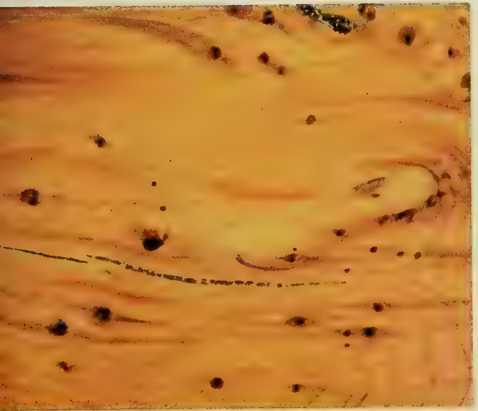
CARPATHIAN ELM BURL—swirl with pin and eye knots



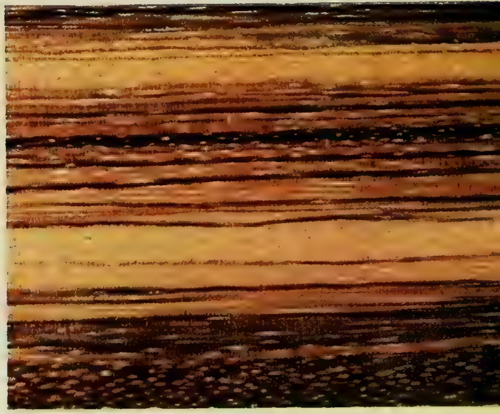
ALPINE BURL—flame figure



LACEWOOD—flake figure



EUROPEAN YEW—Pin and eye knots



ZEBRAWOOD—stripe figure

# Ornamental Eggs of the Insects

## Minute detail decorates intricate forms

By Alvah Peterson

There are, at a conservative estimate, some 660,000 described species of insects. As a result, one may encounter a fascinating variety of insect eggs. Some resemble jewels, some look like miniature flowers, and a few have other unusual characteristics. All insects produce eggs, and most species deposit them on or within terrestrial or aquatic plants, invertebrate or vertebrate animals, or inert objects. To see their intricate details, one must examine them under a 10× hand lens or a stereoscopic microscope. Eggs of the Orthoptera and the Hemiptera are particularly striking and are included in the following descriptions and photographs. Of the former, those of a few roaches (Blattidae), katydids (Tettigoniidae), mantids (Mantidae), walking sticks (Phasmatidae), and crickets (Gryllidae) are outstanding.

A female cockroach may, depending upon the species, produce twelve to fifty or more eggs, which are sealed in a brown, purselike packet, called an oötheca. Each such packet contains two parallel rows of elongated eggs, which are oriented vertically. They are readily visible in an oötheca that has been bleached by a preservative containing acetic acid. The female may carry the oötheca protruding from the posterior end of her abdomen for several days to several weeks, and then drop it in a crack in wood or a crevice along a baseboard or a shelf before the eggs are ready to hatch (Natural History, October, 1961).

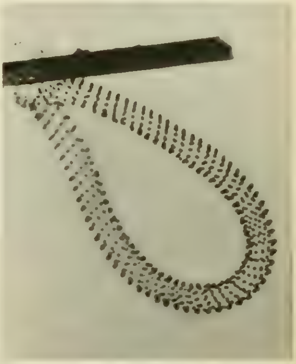
The size of the roach's oötheca varies with the species. In the United States, both the smallest and largest oöthecae are found in Florida. The smallest are produced by minute roaches, species of *Aglaopteryx* or *Plectoptera*. Their packets, which may hold twelve or more eggs, do not as a rule exceed a length of 6 mm. They are found on pine needles, on the lower surface of magnolia foliage, and elsewhere. The largest oöthecae occur in Key West, where they are produced by the large females of *Blaberus craniifera* (Burmeister), which inhabit old buildings, outhouses, and piles of old wood. Their packets are 25 to 35 mm. long, each containing about fifty ova.

Green when laid, geometrid moth eggs turn silvery black before they hatch.

True and false katydids, well-known songsters in the insect world, may deposit distinctive, flattened, disklike eggs in single, overlapping rows along the margin of a smooth leaf or in a double row along two sides of a narrow plant stem. If brought inside during the winter, these eggs may hatch.

An interesting giant katydid, *Stilponochlora couloniana* Saussure, lives in the dense hummocks of Dade County, Florida. The female of this species may deposit thin, wafer-like, cocoa-colored ova on the trunks of large live oaks. Each mass, placed on edge in three to five adjacent and parallel rows, may comprise more than one hundred eggs, and may be more than 60 mm. long.

There are a number of species of beneficial mantids in the United States, some of which have been introduced. In the south, especially in Florida, a small native species, *Thesprotia graminis* Scudder, produces a tiny egg cluster about 6 mm. in length that is found on small branches of pine trees. Another common mantid, *Brunneria borealis* Scudder, which occurs in several southeastern states, produces a slightly elongated, grayish-brown, urn-shaped egg mass with a spoutlike extension at the upper end. When the nymphs hatch they emerge through this spout.



Caddisfly eggs, deposited in water, are sealed in a gelatinous mass loop.

Two large, introduced mantids that were first found in the United States in Pennsylvania and New Jersey produce conspicuous egg masses. Those of the common Chinese mantid *Tenodera aridifolia sinensis* Saussure are round and may occur on weed stems, shrubbery, twigs, and evergreens—especially arborvitae. The egg mass of the narrow-winged mantid, *Tenodera angustipennis* Saussure, is somewhat flattened and elongated, with a ridge that runs lengthwise. It is usually about 12 mm. wide and 30 to 50 mm. long and occurs on the surface of maples and other smooth-barked trees, or on fence posts and telephone poles.

The widely distributed native Carolina mantid, *Stagmomantis carolina* (Johannson), produces an egg mass resembling that of the narrow-winged mantid. However, it is shorter—25 mm. long, more or less—narrower, and may have a light-colored streak along the center mid-ridge. Egg masses of mantids, especially those deposited on shrubbery or trees, may be fed upon extensively by various birds during the dormant season (Natural History, April, 1963).

The walking stick, *Diapheromera femorata* (Say), common in Ohio and neighboring states, produces eggs once a year, late in summer or early in fall. In fact, in a deciduous woodland on a clear day in early autumn, one may hear what sounds like rain striking the dry leaves on the ground. Careful examination of the foliage above or on nearby shrubs may reveal the presence of female walking sticks feeding ravenously and at the same time dropping non-adhesive, oval, hard, shiny eggs. Each egg is bluish gray when deposited, but the color soon changes to near black with a prominent light area on one side. Eggs of the common walking stick are supposed to have a two-year incubation period, but if they are kept continuously at room temperature of 70° ± F. during the winter, some will hatch within six months.

Another large, wingless walking stick, known as the two-striped walking stick because of the two yellow lines running lengthwise along its back, may be seen in Florida and other southern states. In the late summer or fall, this species, *Anisomorpha buprestoides* (Stoll), deposits rough egg clusters, ranging in color from dark brown to nearly black, in sandy soil. If one confines a fertilized female and a male of this species in a large paper bag with a supply of the foliage they consume, a few eggs will be dropped within a day or two. These may be picked up and kept for incubation or preserved in alcohol. The eggs hatch early in the spring.

Tree crickets, especially species of *Oecanthus*, deposit their eggs singly or in rows deep in succulent foliage or within tender stems of young trees or bushes. Some species deposit single eggs in tobacco leaves or similar plant tissue, while another species—probably *Oecanthus nigricornis nigricornis* Walker—lays its eggs in a single row within a tender plant twig or stem.

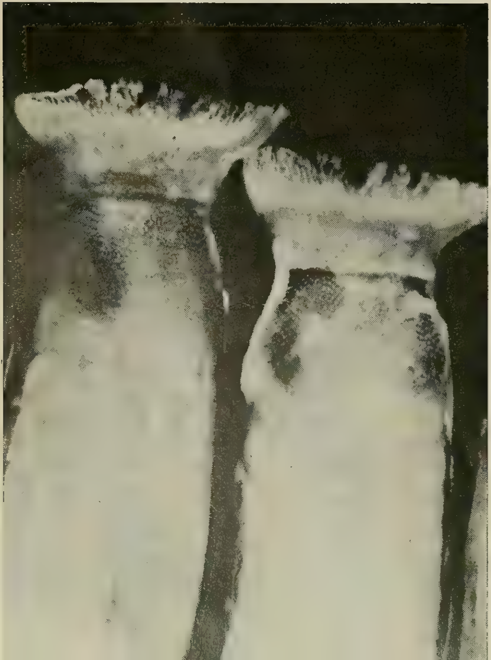
MANY sucking bugs of the Hemiptera produce highly colored, very ornate eggs. This is especially true of numerous stink bugs, family Pentatomidae, and assassin bugs, family Reduviidae. Most species of stink bugs lay eggs with round, detachable caps or lids that are pushed off or lifted when the pronymphs hatch. (When the nymph first emerges from the egg, it is covered with a thin, flexible skin or coat. Before it sheds this covering it is called a pronymph.) To open the cap the pronymph uses a T-shaped, dark-colored egg burster that is located on the top of its head. Upon emergence or during the hatching process, the pronymph sheds its outside coat, including the burster, which may be seen on the tops of hatched stink bug eggs. They are most clearly visible when seen in contrast with a light-colored ovum.

Among the more vivid stink bug eggs are some that are bright red, such as those of *Mormidea pictiventris* Stål, which are deposited in small clusters on plant parts. The color is attributable to the red embryonic tissue inside the unhatched, greenish-white, translucent eggshells.

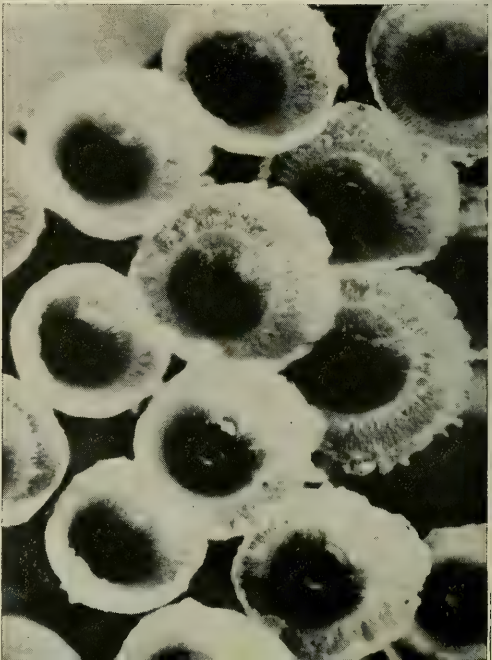
The common southern green stink bug, *Nezara viridula* (Linnaeus), usually deposits its yellow eggs in hexagonal clusters on green foliage, and each cluster contains approximately ninety eggs. Several days after deposition a fertile egg exhibits two red eyespots, a large red V-shaped blotch, and an inconspicuous, near-black egg burster. These are probably located on the embryonic tissue (although the egg burster may be on the nymphal skin) and are visible through the eggshell.

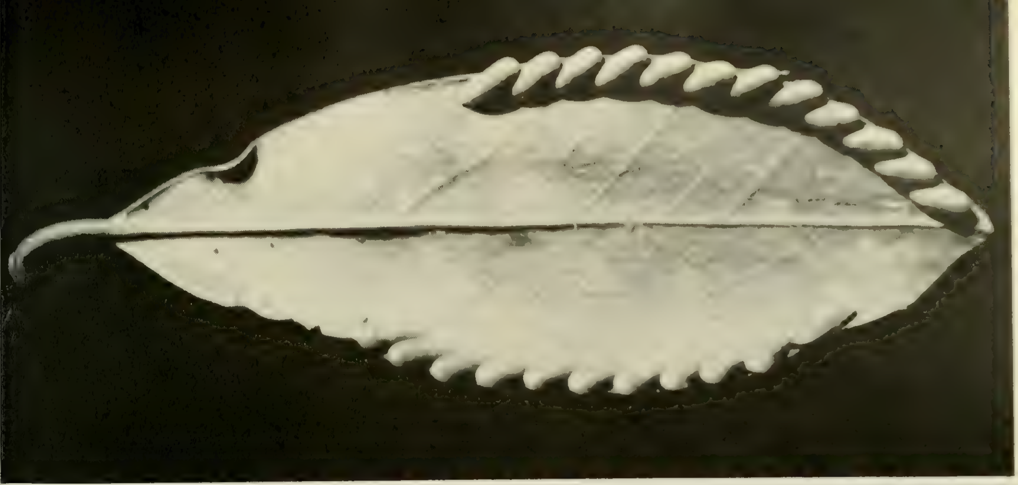
The common harlequin bug, *Murgantia histrionica* (Hahn), lays its eggs on cabbage in small clusters that usually contain two parallel rows of six eggs. Each egg is keg shaped, has black bands about its sides, and is topped with a ringlike cap. Another stink bug, a species of *Brachymena*, often places its beautifully colored,

**DARK SPOTS, actually red, in eggs of the common wheel bug, are eyes of embryo. Light streaks are limbs and mouthparts.**

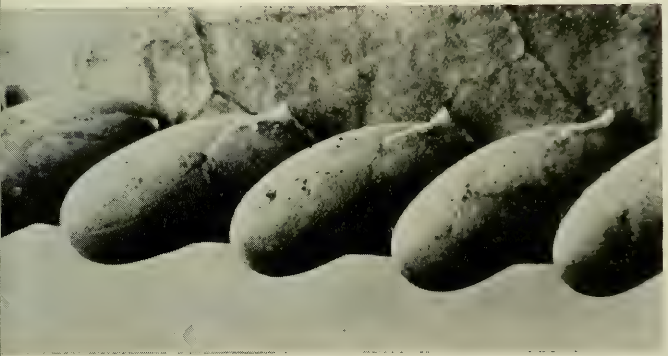


**EGGS of another reduviid, genus *Apiomerus*, are flower-like when seen from above. Tops are white with reddish centers.**



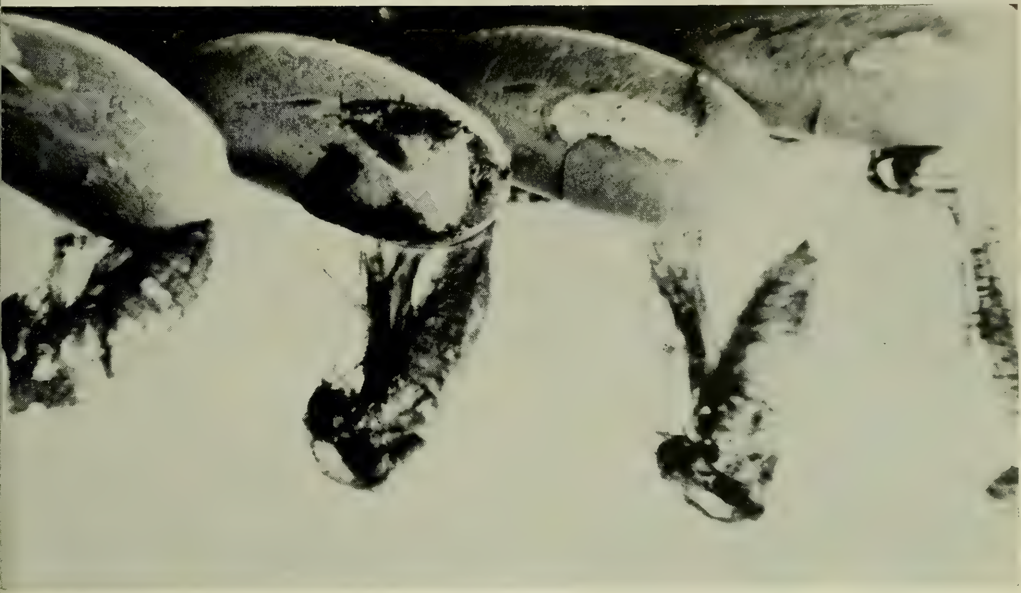


KATYDIDS, of the family Tettigoniidae, often lay light grayish-brown eggs in single rows on edges of smooth leaves.



EGGS stick to the leaf with substance secreted at time of deposition. Other katydids insert eggs in stems or bark.

THESE NYMPHS, less than a fourth of an inch long, perished as they attempted to emerge from egg cases in the spring.



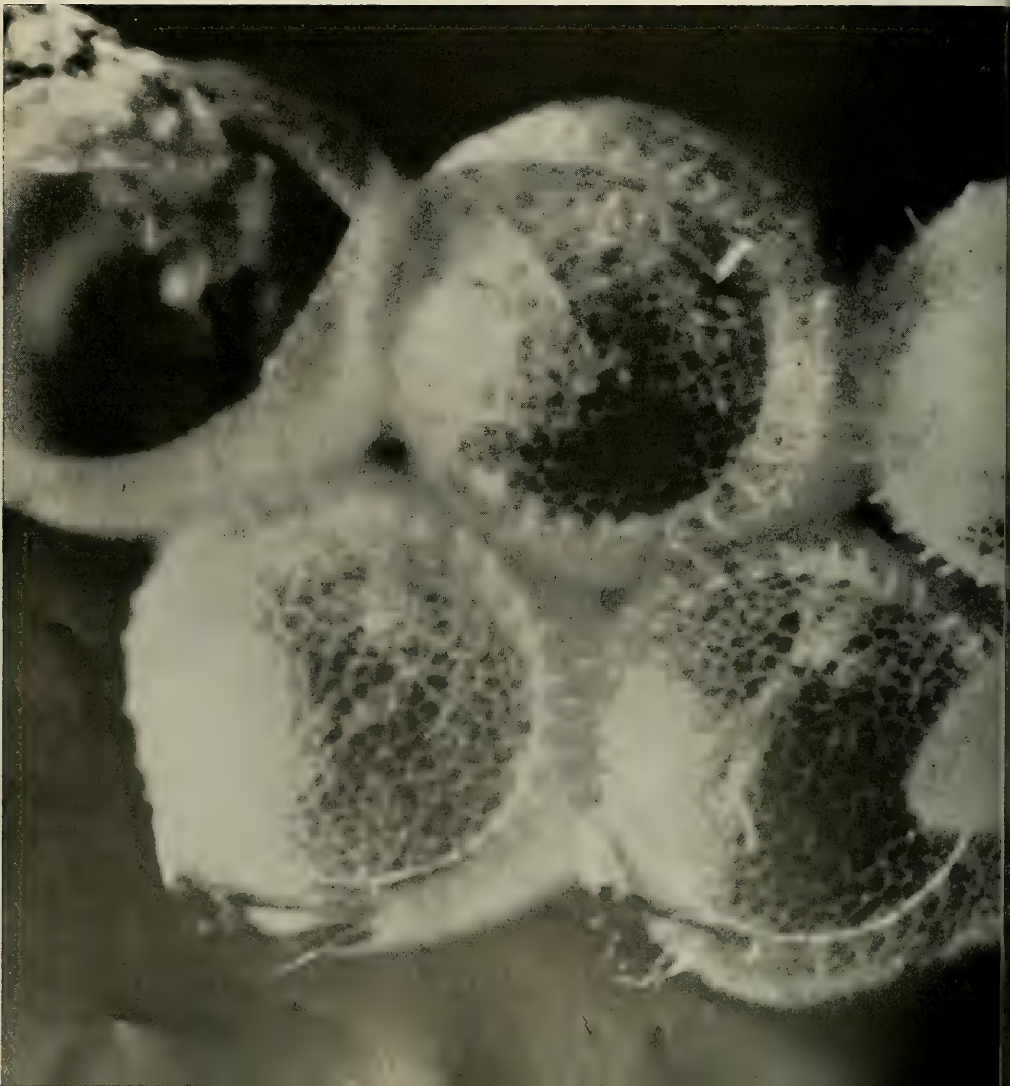
smooth, pearl-like eggs in two rows on a pine needle. Other species of pentatomids produce eggs with a circular row of twelve to fifteen needle-like projections rising from the rounded top. These protrusions may have openings, or ducts, through which male spermatozoa enter to fertilize the eggs.

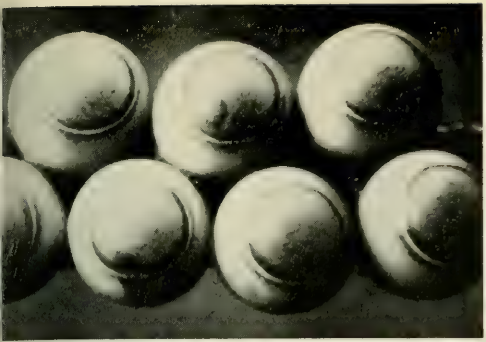
Some assassin bug eggs are extremely ornate, with caps that resemble miniature flowers, such as *Apiomerus crassipes* (Fabricius) and *Sinea diadema* (Fabricius). The wheel bug, *Arilus cristatus* (Linnaeus), a very large assassin bug, deposits elongated, bottle-like, sticky eggs in a vertical cluster on foliage. Each dark-brown egg has a white top similar to the cap on a milk bottle, and when the pronymph emerges, it pushes the cap aside or completely off the egg.

This provides an introduction to just a few of the many, varied types of eggs found in the insect world. Orders of insects other than the Orthoptera and Hemiptera, especially many moths and butterflies, also produce interesting eggs. Butterfly eggs are often notable for their ornate sculpturing and for beautiful colors that may change during incubatio

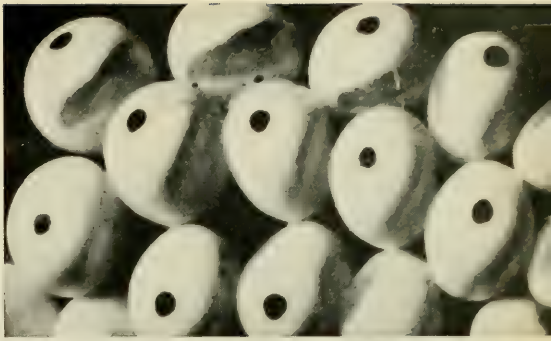
Since detailed recommendations f collecting insect eggs would easily f a book, one example must suffice. T collect moth eggs, one can captu females that have been attracted lights at night, especially "bla lights," which emit mainly ultraviol radiation. The moths can then be co fined in inflated polyethylene or pla tic bags for two or three days, whe many of them will deposit eggs, eith singly or in clusters, on the bag its or on bits of foliage, rough pape wood, or cork enclosed in the ba

**Barrel-like stink bug eggs, genus *Mormidea*, are deposited here in compact rows. Their translucent, near-white shells remain after nymphs have hatched. Projections on tops ar ducts through which spermatozoa entered to fertilize egg**



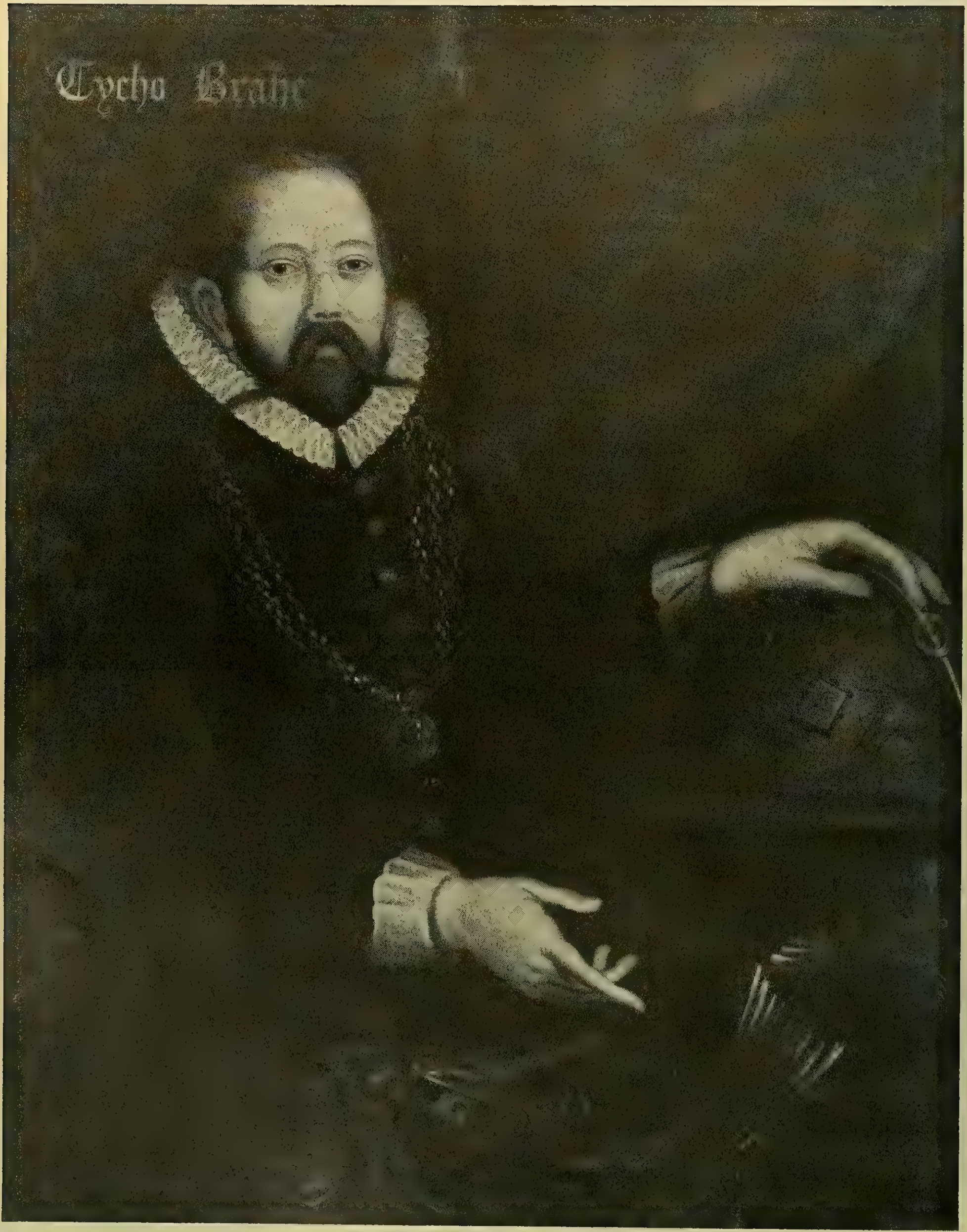


EGGS of a family sometimes look alike, but those of stink bug *Brachymena* are smooth and rounded, unlike those below.



IO MOTH EGGS, laid in clusters, are white with black spots. Their color is of the shell itself, not of the embryo inside.

# Phoenix of Astronomers


Tycho Brahe

In 1546, on December 14, a son was born to Otto Brahe, sometime privy councilor and county lieutenant under King Frederick II of Denmark. The boy was christened Tyge, although he is now better known as Tycho, a latinized form that he adopted. His birthplace was the family estate at Knudstrup, which lies in the southernmost part of the Scandinavian peninsula, then a Danish possession. But Tycho was not left there for long. As soon as a brother was born in the following year, Tycho was stolen away by his uncle Jörgen Brahe. Otto had promised that if he should have another son, his childless brother Jörgen could bring up Tycho.

Tycho's education was designed to train him for a post as councilor or governor, and to this end his uncle sent him to Copenhagen University at the age of twelve, with the avowed intent that he should read law and philosophy. But Tycho was not interested; his real loves were mathematics and astronomy, and this became apparent in 1560 when he was not yet fourteen. In August of that year he observed an eclipse of the sun in Copenhagen. His imagination seems to have been fired because the eclipse actually occurred at the predicted time, and he was determined to find out how such events could be so accurately calculated. He acquired some astronomical tables, and three months later invested part of his allowance in a copy of Ptolemy's *Almagest*. However, this compendium of mathematical astronomy had been written 1,400 years earlier, and it may seem a sad comment on the astronomy of his day that a book compiled in A.D. 150 should still be current in 1560.

The truth is that the aims of astronomy had progressed little since the days when Ptolemy worked in Alexandria. Only one problem still faced astronomers, and that was to explain precisely how the sun, moon, and planets moved among the stars. It was an accepted part of knowledge that they moved in circles at a regular pace, and the astronomer's task was to combine these in such a way that they accounted not only for the forward movement of the planets but also for their apparent retrograde motions and stationary points. In this Ptolemy had been particularly successful, although the facts had forced

### by Colin A. Ronan

him to offset the center of motion a little from the center of the earth, and his ideas had been handed down to later generations, first from Alexandria to the Arabic schools of Baghdad and Toledo, and then, in the twelfth century, to Western Christendom. Ptolemy's ideas had not passed unchanged, however, for written comments were always inserted in the text, so that successive copies of his work reflected the ideas and outlook of the astronomer editing it. For instance, Ptolemy's teachings, as received in the West, were linked with the belief that each planet was fixed to a physical sphere, which, nevertheless, was forever unobservable because it was made of a perfectly clear, crystal substance. And yet Ptolemy's mathematics of planetary motion remained gospel.

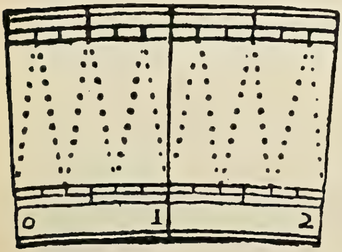
Admittedly a new theory of the universe had been published in 1543 by Nicholas Copernicus, a Polish cleric, who had become dissatisfied with the accepted teaching. After studying ideas that had been suggested in Greek times, Copernicus had evolved his own planetary system in which the sun and not the earth was the center about which the planets moved. But he had made few observations, and his theory was not taught in the universities. Equally to the point, his mathematics was similar to Ptolemy's, and so did not affect the standing of the *Almagest*.

Tycho stayed three years in Copenhagen and then, like many other Danish students, went to study in Leipzig. His uncle died in 1565, when Tycho was nineteen, and the following year the young man arrived at the University of Wittenberg, then one of the most famous in Europe. There he stayed for a brief five months, when he was forced to flee from the plague to Rostock. The University possessed no chair of astronomy, but it did boast of several professors who taught astrology and alchemy, in addition to mathematics and medicine. In the sixteenth century there was no hard and fast line among the subjects. Man was considered the central figure of the universe, and the old belief that each planet exerted its influence on human affairs was widely held. This same belief acted as a stimulant to observation. Accurate horoscopes were needed if the predictions were to be correct, and this in turn meant that the positions and motions of the planets had to be determined as precisely as possible. In consequence, astronomy and astrology went hand in hand, even among scientifically minded men.

A link, too, existed between astrology and chemistry—or alchemy as it was then called (NATURAL HISTORY, August-September, 1963). It arose from the mystery that surrounded the strange processes of chemical change, when so often one substance seemed to be transformed into another. The alchemist found a parallel between generation of life in nature and generation of new substances in the laboratory. Because the planets were thought to affect the organs of the body and, especially, to have a powerful influence on the body fluids, the idea that planetary influences were in operation when chemical changes occurred seemed to follow. The connection between astrology and alchemy was therefore well established, and it is not to be wondered at that Tycho himself became fascinated by both, doubtless a consequence of his Rostock days.

Tycho was impetuous, and at Rostock it resulted in his losing his nose, or at least a part of it. The trouble began over an argument as to who was the better mathematician, Tycho or a fellow countryman, Manderup Parsbjerg. The argument became so bitter that it ended in a duel, and although Tycho's biographers assure us that the two men later became great friends, the young astronomer ever after wore a false nose—some say it was made of gold and silver, others that it was of ivory or brass—to cover his disfigurement, as can be seen from the portrait of him by Michael Mierevelt (*facing page*).

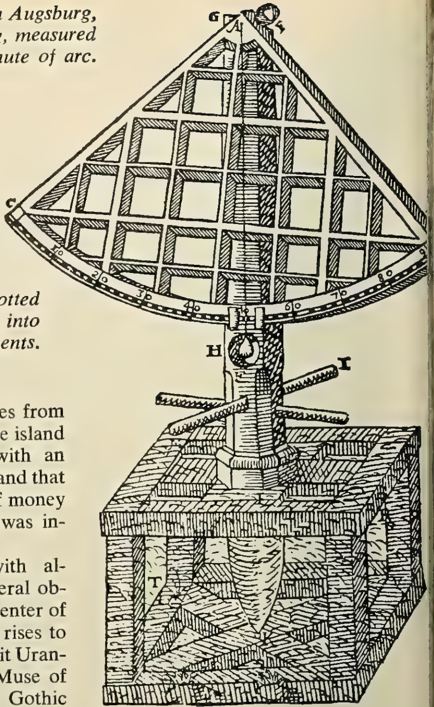
In 1568 Tycho left Rostock for Basel University. The next year he went to Augsburg, and it was here that his flair for designing astronomical instruments began to show itself. Tycho became friendly with an alderman, Paul Hainzel, to whom he used to bemoan the inaccuracy of astronomical instruments, such as the cross-staff, that could measure to an accuracy of no more than ⅓ of a degree—"puerile tools," he called them. Tycho wanted to be able to measure star positions to fractions of a minute of arc, and Hainzel, who was much interested in astronomy, agreed to pay for a large quadrant, built to his young friend's design. This had two straight arms separated by 90 degrees or a quarter of a circle (hence its name), with a curved arm joining them, and the whole device was pivoted on a stout pillar. It was exceptional in the care with which it was made. Constructed of well-seasoned oak, with each of its straight arms 19 feet long, it took the united efforts of twenty men to erect it. Yet its graduated arm carried a brass scale that was so meticulously marked with divisions for each minute of arc that it was possible for fractions of a minute to be estimated with confidence. At least, this was its theoretical accuracy, but in practice the pivots of the instrument and its general construction did not permit measurements of such precision.



*Tycho used transversals (dotted lines at left) to divide arc into minutes for angular measurements.*

That Tycho Brahe had a flair for designing accurate observing instruments, however, shows up best in the work he did in establishing his own observatory on the island of Hveen. Although nothing but a few stone ruins now remain of what, in the sixteenth century, was the world's largest observatory, we do know from Tycho's own book, *Astronomiae Instauratae Mechanica* ("Mechanics of the Renewed Astronomy"), published in 1598, and from the work of his assistant Willem Blaeu, full details of his instruments and their mode of operation. Hveen, which lies between Elsinore and Copenhagen, is no more than three miles from end to end. It was given to Tycho by King Frederick II of Denmark in May, 1576, complete, as the royal decree put it "with all ... the crown's tenants and servants who thereon live, with all rent and duty which comes from that. . . ." Considering that the island is good agricultural land with an abundance of game and fish, and that the King also added a sum of money toward building a house, it was indeed an extraordinary gift.

The house, complete with alchemical laboratory and several observatories, was built in the center of the island where the ground rises to some 160 feet. Tycho named it Uraniborg, in honor of Urania, Muse of astronomy. It was a large Gothic Renaissance building, designed by a German architect, and with its slender spires and decorated gables, its delicate appearance was a novel departure from the heavy medieval style of contemporary Danish architecture. Here Tycho designed and built instruments more accurate than any the world had known before.



*Large quadrant built in Augsburg, with arms 19 feet long, measured star altitudes to a minute of arc.*

Most of the instruments were large, like the Augsburg quadrant, since this permitted the use of scales of considerable length, so that errors in scribing the divisions on them were of less consequence than they would have been on scales of smaller size. Moreover, Tycho used a novel way of dividing his scales so that he could read accurately to fractions of a division. His method was based on the use of transversals (diagonal lines drawn between the divisions on a scale), which had been devised at least fifteen years earlier. Tycho's innovation was that he adapted the idea to the curved scales on astronomical instruments, and substituted equally spaced dots for the lines. As a result, he was able to read directly to a tenth part of a division—that is, to one minute of arc. By estimate he could make measurements consistently to fractions of a minute.

This was not only because of the engraving of the scales, but also because of the construction of the instruments themselves. Tycho insured that they were rigid, since the most accurate scales were useless if the instrument to which they were fitted gave flexure in any direction. He therefore braced the wooden instruments with brass or steel plates and even had some of his observing instruments made entirely of metal—another innovation. What is more, when experience showed him that wind blowing on his larger instruments affected the accuracy of some of his observations, he built a subterranean observatory outside the walls and to the south of Uraniborg. He called it Stellaeburgum (Stjerneborg in Danish), and here all the large instruments were mounted well below ground level; only the domes of the buildings appeared aboveground (NATURAL HISTORY, June-July, 1964). In this way, errors caused by the wind were avoided.

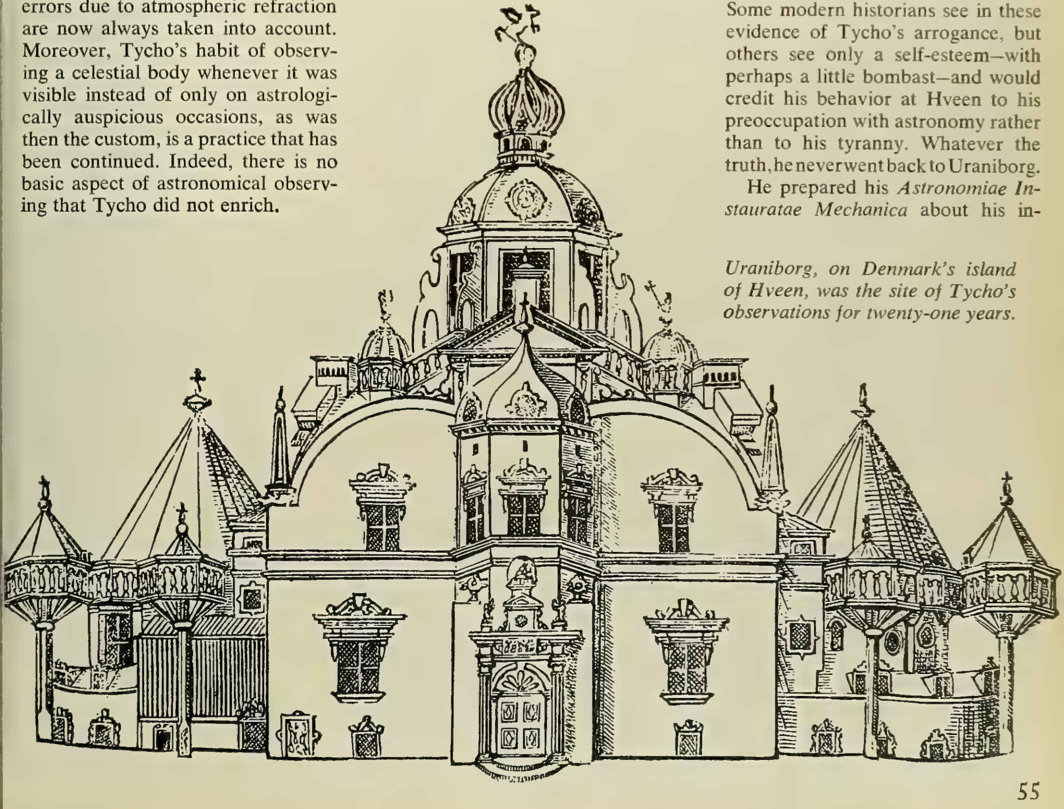
With all their refinements, which

included a new design permitting fine adjustment to the alignment of the lensless sighting tubes, Tycho and his assistants made the most accurate observations the world had ever seen. Part of their success was due to Tycho's appreciation of the apparent displacement of stellar images caused by refraction through the atmosphere and his efforts to allow for this error. But above all, his success was due to his insistence that the errors inherent in any instrument, however well made, should be taken into account. This understanding of instrumental error was, again, an innovation, and went far in helping him to achieve regularly what in the sixteenth century was an outstanding degree of precision. The late Professor Dreyer, by comparing modern star positions with those obtained at Hveen, has shown that Tycho achieved a consistent accuracy of at least one minute of arc, an improvement of five to six times over the best of his contemporaries. But his work did more than this, for it laid the foundations of modern observing methods in astronomy. Instrumental errors and the errors due to atmospheric refraction are now always taken into account. Moreover, Tycho's habit of observing a celestial body whenever it was visible instead of only on astrologically auspicious occasions, as was then the custom, is a practice that has been continued. Indeed, there is no basic aspect of astronomical observing that Tycho did not enrich.

He only remained at Hveen for twenty-one years, for in 1597 he and his family were driven from the island. Their exile is a tragic and muddled story. Tycho had trouble with his tenants, and he failed to fulfill some of his overseeing responsibilities under the crown. When King Frederick died in 1588, the situation went from bad to worse. The new government appeared to support him at first, but some of his enemies at court, doubtless jealous of his position, thought him too self-willed and too highly paid. They began to agitate for his removal from the island, and by 1597 things had become so difficult that he took his family and many of his instruments across to Copenhagen. Here he was forbidden to set up an observatory and could only continue his alchemy. After three months, therefore, he moved with his instruments to Germany, where he stayed for two years and looked for a new patron.

How much Tycho himself was responsible for his expulsion from Hveen we shall probably never know. He certainly held himself in high esteem, as one of the inscriptions over the entrance to Stellaeburgum, which he quoted in his *Astronomiae*, makes clear. Part of it runs ". . . Tycho Brahe, son of Otto, who realized that Astronomy . . . still had not . . . been purified of errors, in order to reform it and raise it to perfection, invented and with incredible labor, industry and expenditure constructed various exact instruments suitable for all kinds of observations of the celestial bodies . . . and consecrating this very rare and costly treasure to you, you glorious Posterity . . . adjures you that in honor of the eternal God . . . you will constantly preserve it . . . out of reverence to the Creator's eye, which watches over the universe." Again Professor Dreyer recorded that on the ceiling of the underground study were eight portraits of astronomers, ranging from the Greek Hipparchus to Tycho and a mythical successor named Tychonides who was exhorted to be worthy of his great ancestor. Some modern historians see in these evidence of Tycho's arrogance, but others see only a self-esteem—with perhaps a little bombast—and would credit his behavior at Hveen to his preoccupation with astronomy rather than to his tyranny. Whatever the truth, he never went back to Uraniborg.

He prepared his *Astronomiae Instauratae Mechanica* about his in-



*Uraniborg, on Denmark's island of Hveen, was the site of Tycho's observations for twenty-one years.*

struments and observations and dedicated it to the astronomically minded Emperor of Austria, Rudolph II. He also had a few manuscript copies drawn up of his catalogue of 777 stars and added some additional, but not so accurate, observations to bring the number up to 1,000. He presented a copy of each to Rudolph II in January, 1598. The Emperor responded by taking him into his service and giving him the castle of Benatky, situated on the banks of the river Iser about 22 miles northeast of Prague. Here Tycho established an observatory and here, as to Hveen, came pupils and assistants, attracted by his fame. The astronomer Longomontanus, who for a time had been with him at Hveen, worked at Benatky, and thence came Johannes Kepler, already a man with a substantial reputation.

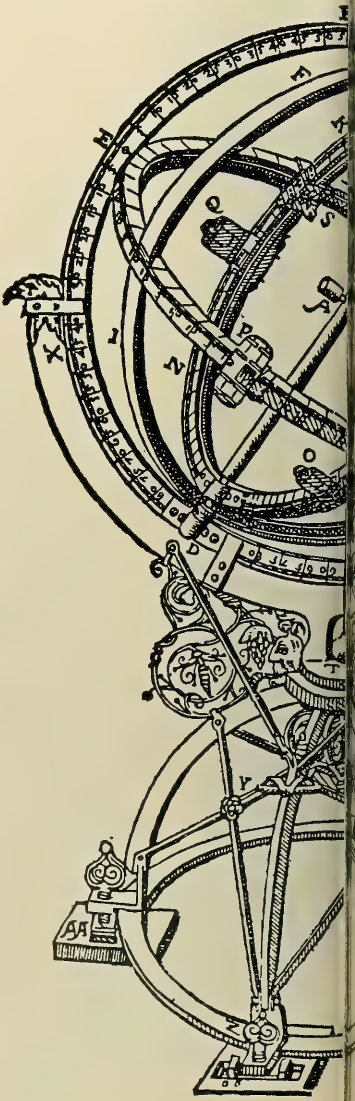
Tycho's fame rested not only on his instruments and observatory at Hveen, but also on the actual observations and discoveries he had made, and on his theory of planetary motion. He had come to public notice in 1573 with *De Nova Stella,* a small book about a new star that had first appeared in November of the preceding year. Modern research has made it clear that this was a supernova, since records show that its brilliance can only be accounted for by supposing that it was an exploding star that shot most of its substance out into space as an immense glowing envelope of gas. The supernova of 1572 was so bright that, for a time, it could be seen in daylight. In company with other careful observers of the day, Tycho discovered a strange fact: the supernova was farther away than the moon. Today this is what we should expect, but in the sixteenth century it was revolutionary, since it meant that an actual change had occurred in that part of the heavens that lay farther away than the moon. This was in direct opposition to the accepted view that the heavens beyond the moon were immutable, and that any change in the sky must have a meteorological explanation. Tycho had thus made observations of real importance, and although they made little impression on his fellow countrymen, they caused a considerable stir among continental astronomers.

His next important set of observations concerned a bright comet that appeared in November, 1577, causing much interest among the learned and concern among the public, who still believed that a comet was an omen of disaster. Tycho made many observations of it and also collected information from other European astronomers. In 1588 he published his results and made it clear that the comet, like the supernova of 1572, lay far out in space. Because its path cut across the heavens, it had apparently cut through the "crystalline spheres" of the planets, which made the spheres' existence questionable.

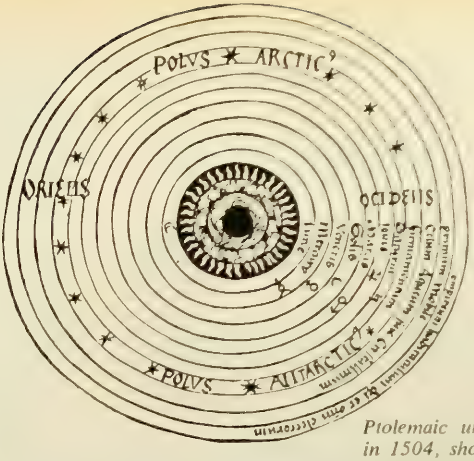
Tycho had therefore produced evidence that at least indicated a new outlook was required, and it is characteristic of him that he should set about supplying this himself. He disliked the moving earth hypothesis of Copernicus, because he considered it against scriptural teaching. Equally important, he could find no evidence of a parallactic shift of the stars that should be observable if the earth moved. We now know that excellent though his observations were, they did not reach the accuracy required to show this phenomenon, which, for even the nearest stars, amounts to no more than 0.76 of a second of arc. It took another two and a half centuries before an accuracy more than sixty times better than Tycho's could be achieved, and stellar parallax measured. Tycho, obtaining no perceptible result, devised his own planetary system. In this the earth was stationary in the center of the universe, with the sun and moon orbiting around it, as in Ptolemy's system, but with the important difference that the remaining planets orbited around the sun. It was in essence a compromise between the thoroughgoing heliocentric theory of Copernicus and the entirely geocentric system of Ptolemy, with the advantage that it did no violence to scripture.

In many quarters Tycho's theory met with considerable success, especially among the Jesuits, and in France it was still to be found supported well into the middle of the next century. Tycho himself had great faith in it, and when he passed his planetary observations on to Kepler at Benatky he said that he hoped they would make Kepler agree with him. But Kepler found that the observations showed both Tycho and Copernicus to be wrong, and that all the planets moved, not in circles, but in ellipses around the sun.

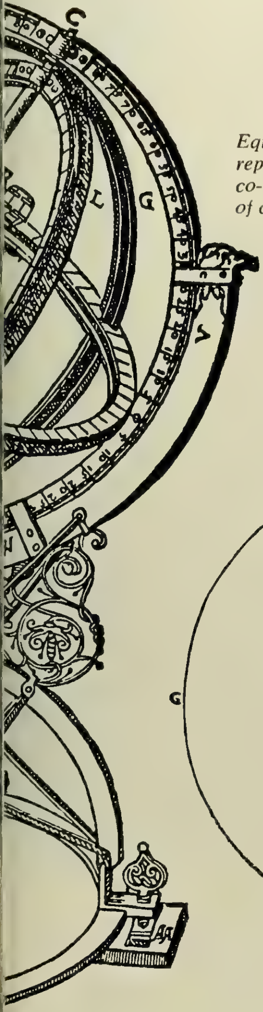
Tycho did not live to learn of Kepler's results. On October 24, 1601, he died, and Kepler was to have eight more years of hard work before he began to solve the riddle of planetary motion. Yet without Tycho, Kepler would not have been able to reach his epoch-making conclusions, as he himself was always ready to acknowledge. Without Tycho the art and science of observing the heavens with



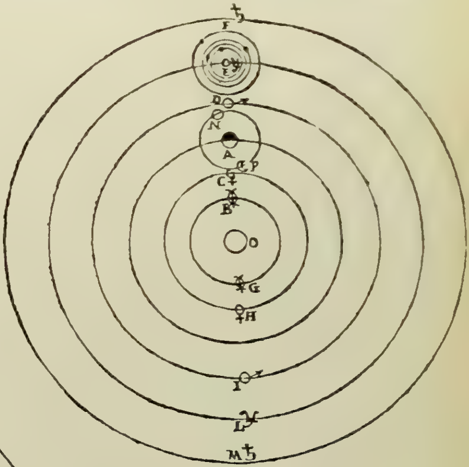
great precision might have taken far longer to develop. In fact, as Kepler said, "Tycho possesses the best observations and consequently, as it were, the material for the erection of a new structure [in astronomy]." Whatever we may think of Tycho's theoretical work, of his predilection for astrology and alchemy, it is clear that he was most important as an observer. In Kepler's words, Tycho was the "Phoenix of astronomers"; indeed, through the accuracy he attained, astronomy was truly reborn.



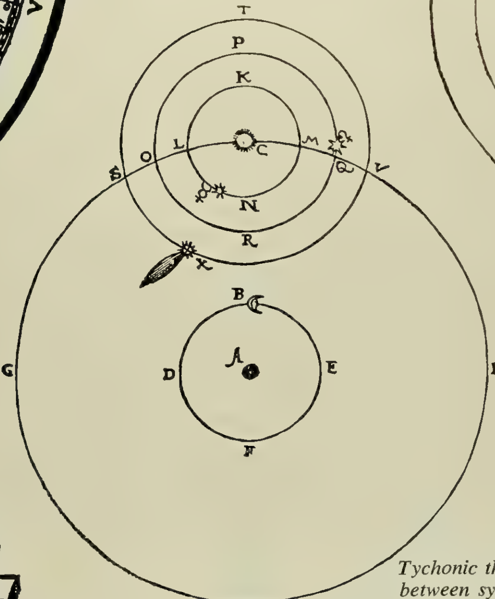
*Ptolemaic universe, as rendered in 1504, showed earth in center surrounded by orbiting sun, moon, and planets, and sphere of stars.*



*Equatorial armillary, with rings representing system of celestial co-ordinates, aided in preparation of catalogues of the star positions.*

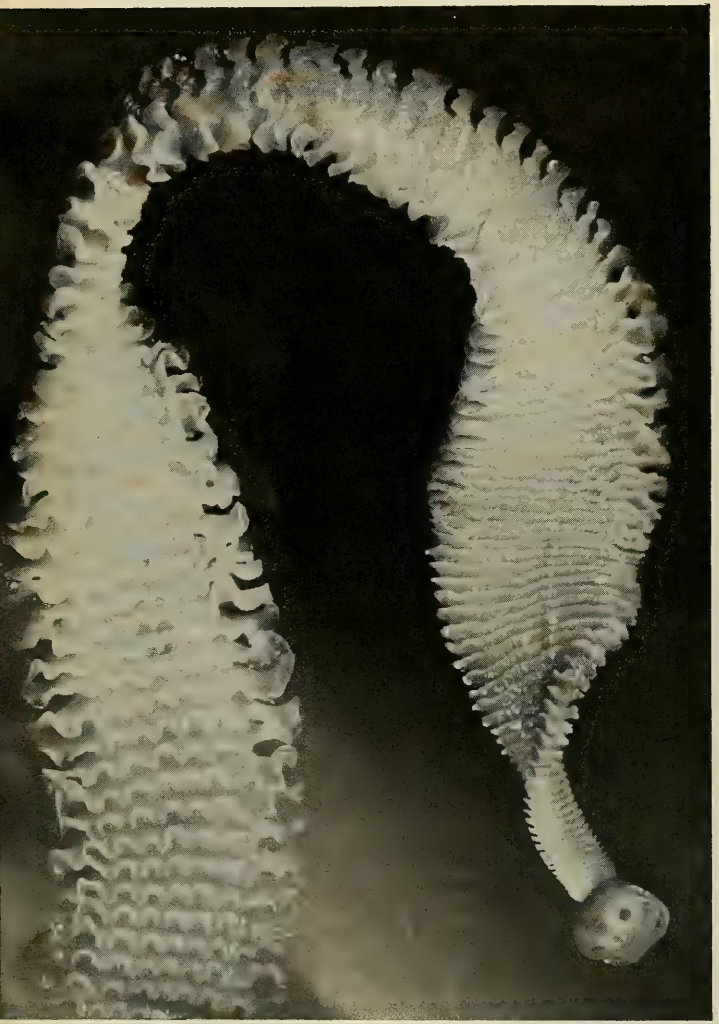


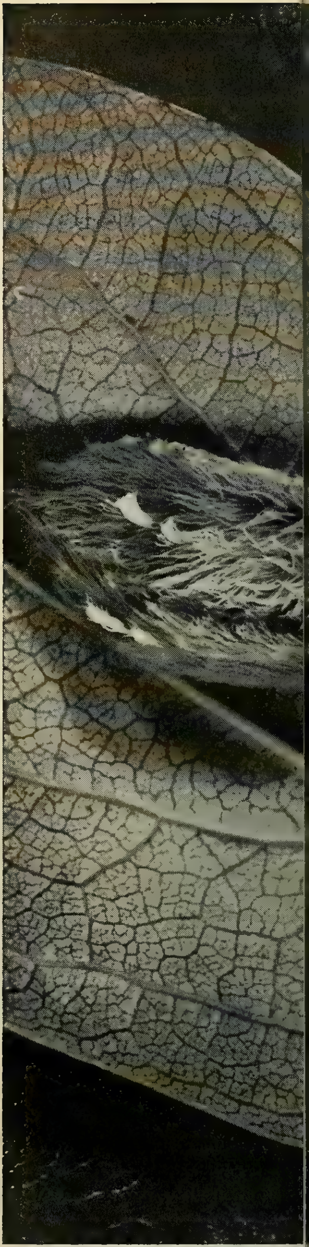
*Copernicus placed sun in center of universe with earth and other planets revolving around it. This conception was published in 1632.*



*Tychonic theory was compromise between systems above, with sun and moon orbiting earth (A), and other planets orbiting the sun (C).*

# The Art of The Biological Photographer

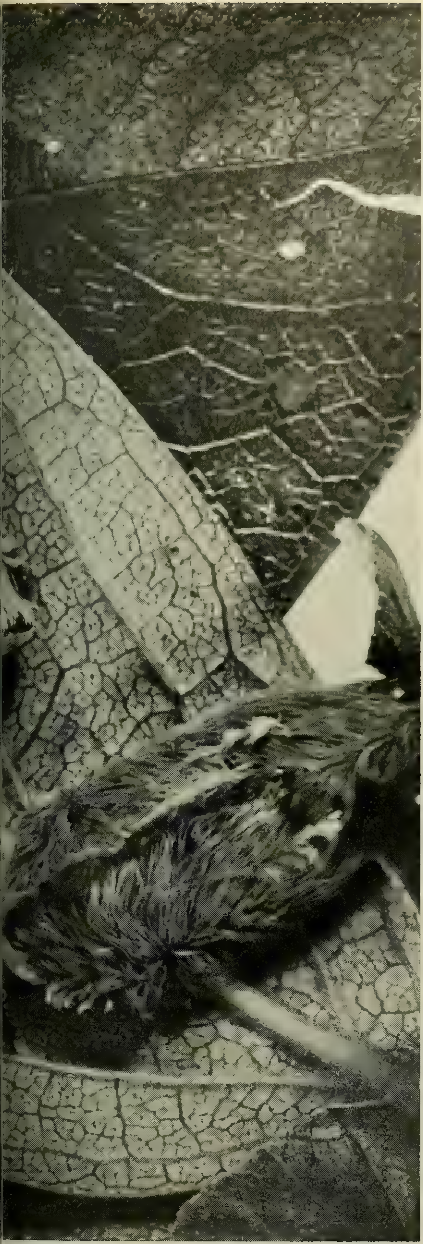




**AFRICAN TAPEWORM**

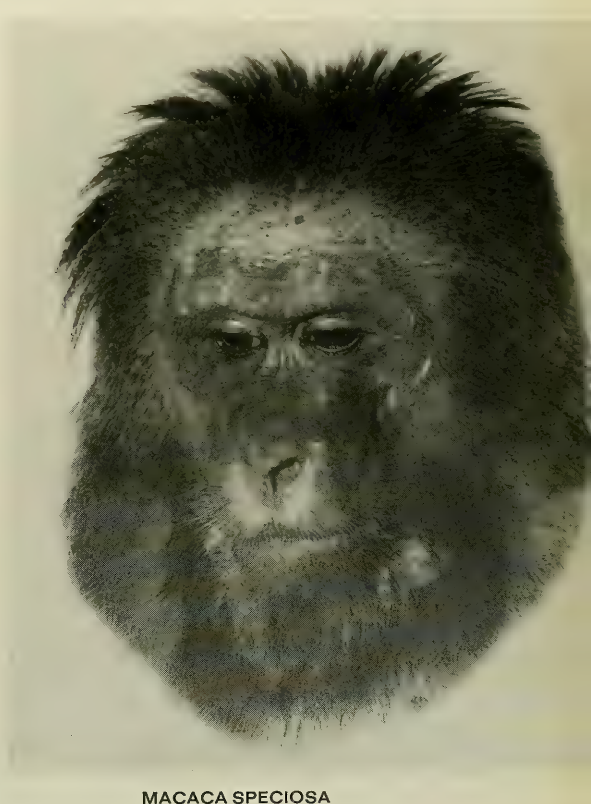
*A glass-topped table, a reflector, and a lamp with diffuser all helped to achieve the detail present in this photo by Luvenia C. Miller of the Armed Forces Institute of Pathology.*

The photographs on these and the following two pages are from the various natural science subjects that were recently displayed at the annual convention of the Biological Photographic Association, held this year in New York City. Founded at Yale University in 1931, the aims of the Association are to advance the study and the application of photography in relation to the biological sciences and to improve its technique. In meetings and publications, the Association's nine hundred members exchange ideas and keep abreast of new equipment or approaches being used. While the majority of the membership is involved in the medical field and includes men and women who are medical photographers and illustrators, physicians, or X-ray technicians, "biological" is interpreted to encompass the photography of all things that live or have lived. As these four pages bear out, the natural sciences are well represented, both by a wide range of subject matter and a wide variety of techniques employed to produce these outstanding pictures.



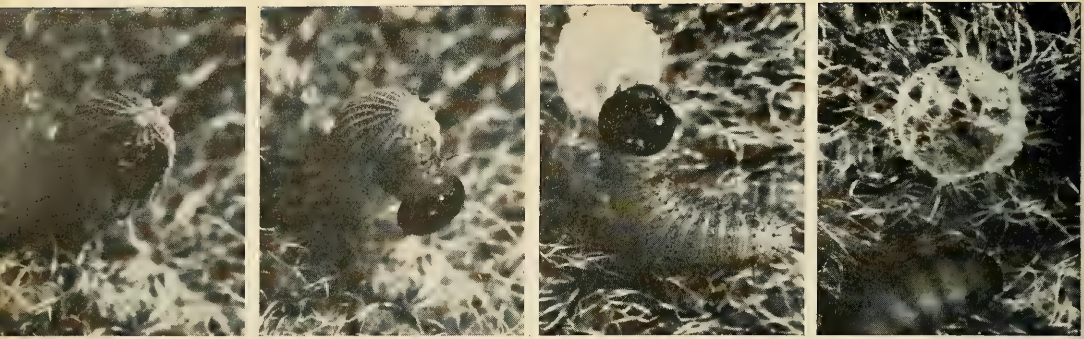
**GENUS LOGEA PYXEDIFERA**

*Ethel McM. Brown, who is a medical illustrator at the Medical College of South Carolina, used a six-inch Goerz-Dagor lens to photograph the two caterpillars feeding on a leaf.*



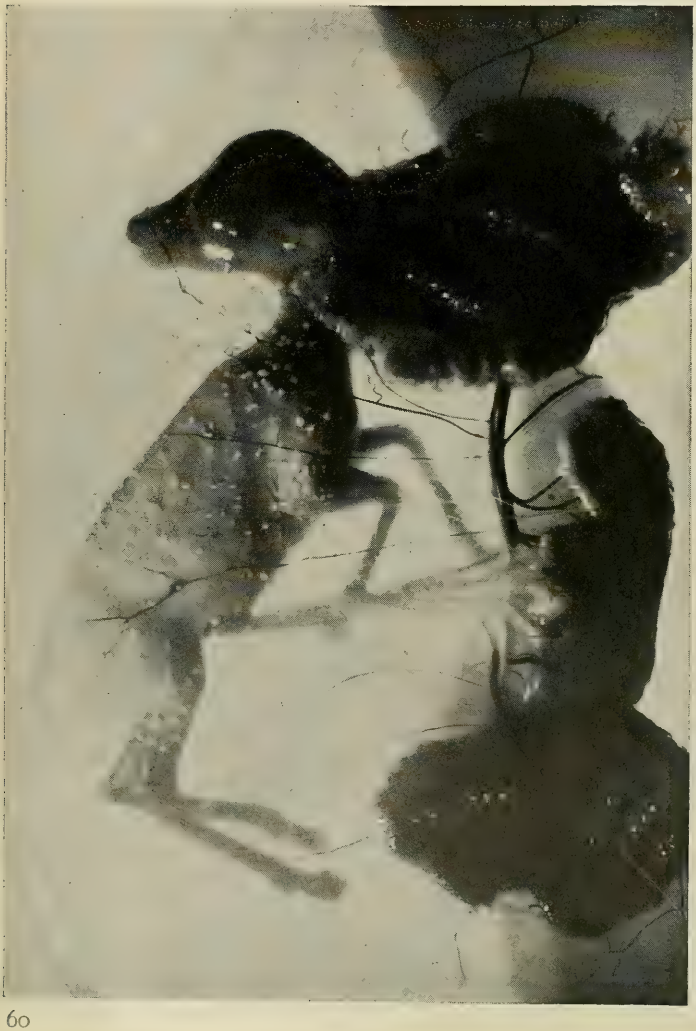
**MACACA SPECIOSA**

*Bronica S camera, hand-held, was employed for portrait of stump-tailed macaque. The photographer, Lois L. Wright, is on staff of the Oregon Regional Primate Research Center.*



**INSECT BEHAVIOR**

*In this sequence, part of a longer one taken at one-minute intervals by Colin Burdall, the larva of a monarch butterfly hatches and then proceeds to devour empty eggshell.*



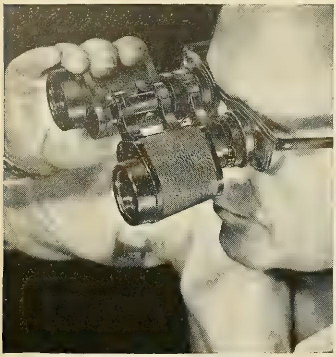
**MULE DEER FETUS**

*Donald H. Fritts, medical illustrator at Montana State College Veterinary Research Center, used glass table with illumination above and below to capture fetus's delicate texture.*

**SAW-WHET OWL**

*With camera and flash clamped in tree, Hans Dommasch waited. Th owl returned, carrying a mouse, an from 25 feet away Mr. Dommasc tripped the shutter by air release*

don't remove your glasses



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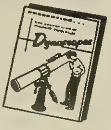

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# About the Authors

"The Sea Gypsies of China" is the work of Dr. Wilmon Menard, who has written for many American and foreign publications and has just completed an anthropological study of the women of Tahiti and French Oceania. He studied at the University of California at Berkeley and did graduate work at the Sorbonne, achieving doctorates in sociology and philosophy. He has written for Natural History in the past.

Dr. Virgil N. Argo, a frequent contributor to Natural History, wrote "The Bull-horn Acacia." Before retirement, he was Associate Professor of Biology at The City College of New York.

Dr. Allen Keast, who wrote "Australia's Spotted Diamondbirds," is President of the Royal Australasian Ornithologists Union, a Research Fellow in the Department of Ornithology at the American Museum, and an Associate Professor of Biology at Queen's University, Kingston, Ontario, Canada.

Dr. John A. Day, author of "The Building Blocks of the Clouds," was graduated in the first airline meteorology class at Boeing School of Aeronautics in 1937 and subsequently worked as a meteorologist for Pan American Airways. He received his Ph.D. in 1957 from Oregon State University, writing his thesis in cloud physics on the nucleation of small water droplets. He collaborated with Dr. F. W. Decker on the book *Rudiments of Weather,* and in 1961 coauthored *Water, the Mirror of Science.* During 1962-63, Dr. Day was an N.S.F. Science Faculty Fellow in the Department of Cloud Physics, Imperial College, London. He teaches at Linfield College in McMinnville, Oregon.

"Patterns in Wood" was written by Paul Villiard, who has taught veneering, cabinetmaking, and woodworking for many years, and is now writing a book on veneering. He collects rare veneers and designs furniture according to the figure, grain, and color of each species. He is also a biophotographer and writer on natural history subjects.

Dr. Alvah Peterson, Professor Emeritus at The Ohio State University, wrote "Ornamental Eggs of the Insects." Dr. Peterson has published many papers and books on the biology of insects and is currently preparing a book on insect eggs based on research conducted under a National Science Foundation grant. He was an undergraduate at Knox College, received his Ph.D. from the University of Illinois, and was Professor of Entomology at Ohio State from 1928 to 1958.

Colin A. Ronan, author of "Phoenix of Astronomers," is Director of the Historical Section of the British Astronomical Association, a Fellow of the Royal Astronomical Society, and also a Member of the Junior Astronomical Society.

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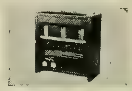

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**SCIENCE IN ACTION**

# New age for hydrology

### By Raymond L. Nace

EDITOR'S NOTE: In this magazine just one year ago (January, 1964), Dr. Nace, in an article entitled "Water of the World," emphasized the global aspects of water problems. He also mentioned the probability of an International Hydrological Decade, to begin in 1965. That probability has now become an accomplished fact. Here Dr. Nace discusses the philosophic and economic implications of the next ten years of study and co-operation among many of the world's nations.

IT has been said that the mark of the true scientist is that he addresses himself to the central problem of his time. This sounds a bit opportunistic. Perhaps the true-blue scientist should attack the central problem of the near future, because he can have an impact only on the future. The scientific discovery of today is the working knowledge of tomorrow, and discoveries have no effect until they are put to work.

One drawback to dealing with the future, however, is that most people prefer to ignore it until it acquires present tense, imperative mood. In the case of water difficulties, both the opportunist and the prophet are on sure ground. Water is a central problem *now* in many parts of the world, and in the clearly visible future it will be a central problem just about everywhere. For that reason, interest should be widespread in the IHD — International Hydrological Decade — which may turn out to be the most important long-range international program yet organized to help make human knowledge serve human welfare.

The IHD will begin in January, 1965, with about sixty countries already pledged to participate and more certain to join in. As the New Year rolls in, no rocket will whiz to commemorate the occasion and no satellite will go into orbit for television. It is not that kind of program; the beginning will be modest.

Special training schools will be organized to improve the competence of hydrologists in undeveloped countries; scholarships will be awarded so that some of the best may do advanced studies in well-established research centers. Scientific missions will be dispatched to help countries organize their scientific services and plan their water-development activities. Universities and government agencies in various countries will exchange professors and scientists on tours of duty for mutual stimulation and joint study of common problems. Scientists in different parts of the world will be writing handbooks, textbooks, and manuals of hydrology adapted to the special needs of the less-advanced countries. These and many other related activities will be sponsored by international agencies, such as the United Nations Educational, Scientific and Cultural Organization, the World Meteorological Organization, the Food and Agricultural Organization, the World Health Organization, and the International Atomic Energy Agency, and by scientific associations—modest programs because these agencies have modest budgets.

The operational program will consist chiefly of the activities of member states of UNESCO, who will be largely responsible for the staffing and financing of their own activities. These activities will range from the reading of a simple staff gauge on a river to installing an automatic recording gauge; from measuring the discharge of a river past a given point to computing the water balance of an entire continent; from measuring the movement of a glacier to computing the mass balance of glaciers and icecaps of the world; from measuring the water level in a well to estimating the submarine discharge of ground water into the sea; from reading a rain gauge to estimating the water balance of the atmosphere; from simple applied tasks having immediate utility to less pragmatic tasks whose benefits lie largely in the future. In short, the program will consist of many studies, large and small, any one of which may be insignificant in itself, but in the aggregate the studies will form the indispensable basis for the task of enabling men to use a finite supply of water to meet a limitless demand.

WATER, one of the simplest of chemical compounds (if any compound is simple), is the greatest common denominator of the earthly environment so far as organisms are concerned. Water is present in the atmosphere to a height of more than 90 kilometers, and in the rocky mantle of the earth to at least an equal depth. Water is the tear of compassion, the mist rising from the swamp, the rippled lake, the restless sea. It is the creeping Antarctic icecap; as exploding steam, it is the prime mover of some of earth's greatest volcanic upheavals. In rivers, it is the endless file that sculptures the face of the earth. All these phenomena imply movement — perhaps the most important property of water.

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The cycle of water movement—by evaporation from ocean to atmosphere, by precipitation on land, and by runoff back to the sea—has been called "Nature's Perpetual Motion Machine." This characterization is not wholly apt, because by definition a perpetual motion machine, once set moving, would continue forever without application of new energy. Nature's water machine, however, moves only because new energy is applied and transferred continually. The chief source of energy is the sun, and the amount is tremendous. It is estimated that vapor transformations in the water cycle—evaporation and condensation—involve an annual energy transaction of $3 \times 10^{22}$ calories.

When the weather reporter describes the antics of hurricane Desdemona—or Delilah or Jezebel, as the case may be—we think of her principally as a potential source of foul weather, which she is. But she is also one of nature's water wheels. The air mass in a hurricane 500 miles across may contain on the order of 5 to 10 cubic miles of water weighing in the neighborhood of 5 to 10 billion tons. The air mass may transport this water thousands of miles from the places where it evaporated from the sea to the places where it falls as rain. Other less spectacular but generally more effective air movements accomplish the main global, continental, and local atmospheric transport of water.

The point is that the occurrence and distribution of water in any part of the globe is a consequence of its occurrence and movement in all other parts of the globe. In addition, global aspects of water are closely related to certain atmospheric phenomena that have had widespread attention in international geophysical studies. What then could be more appropriate than co-operative international scientific study of water?

We hear much brave talk about rain making and "weather modification." But if scientists ever devise an effective cloud wringer or find a way to get a bigger dipper in the rain barrel, it will be on the basis of a much better understanding of water and of the atmosphere than is available now. The IHD is an effort to gain better understanding—not, however, for the distant prospect of tampering with climate and weather, but for the immediate need to predict the natural water yield of weather a year and more ahead. These predictions should include the time and place of the water yield as well as its quantity.

MAN takes quite literally the ancient Judaic assertion that he shall inherit the earth. He has spread into every corner of it and now threatens to infest other planets as well. However, if one scans recent population figures in the light of a cold winter dawn, he may sus pect that man is multiplying his way into

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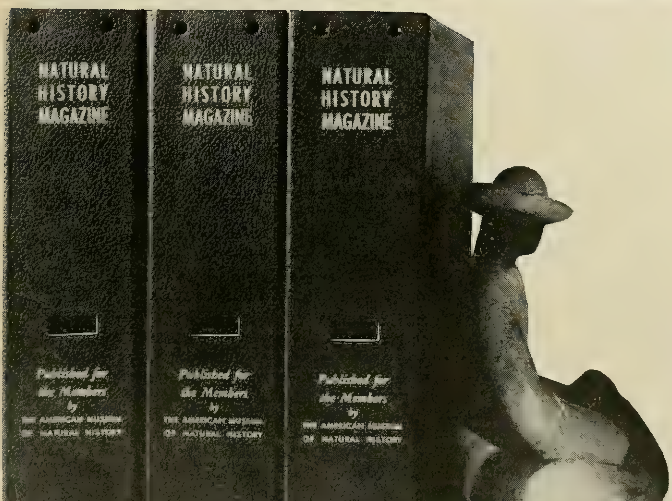
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oblivion rather than ejecting himself into the distant lap of Venus. Be that as it may, life must go on, since none of us is willing to give up, and somehow we must face the problems that our sons will inherit along with the legacy of a rather moth-eaten (or man-eaten) world. These future problems will be vastly more complex and numerous than any we face now, although their nature can be rather clearly foreseen. I do not speak merely of individual misery or well-being or yet of internal national problems. In some parts of the world today, armed forces confront each other, poised for conflict over the most common commodity in earth—a commodity whose lack would bring national disaster. These situations will multiply and increase in gravity unless men make faster progress in their ability to cope scientifically with water.

The IHD is planned as a decade of progress. A recent study in 75 "less-developed" countries discloses that 130 million people depend on water supplies that are inadequate, unhealthy, or both. Another 80 million have water situations that few Americans would tolerate. Within 15 years, 340 million people in those countries will have unsatisfactory and dangerous water supplies unless drastic improvements are made continually, starting immediately. Thus the "decade" probably will extend in some form to a longer or indefinite period.

Problems are not confined, of course, to the poor countries. Those of the developed countries will be staggering. The profligate waste and reckless abuse of water in the United States has created a situation in which it will cost billions of dollars merely to clean up existing water supplies, to say nothing of the cost of protecting them from the tremendous production of wastes by expanding industry and growing population.

The industrialized nations, however, have several important advantages aside from their economic viability. One advantage is that their governments recognize the economic and social importance of science and provide financial support for it. This is not true in perhaps a majority of poor countries.

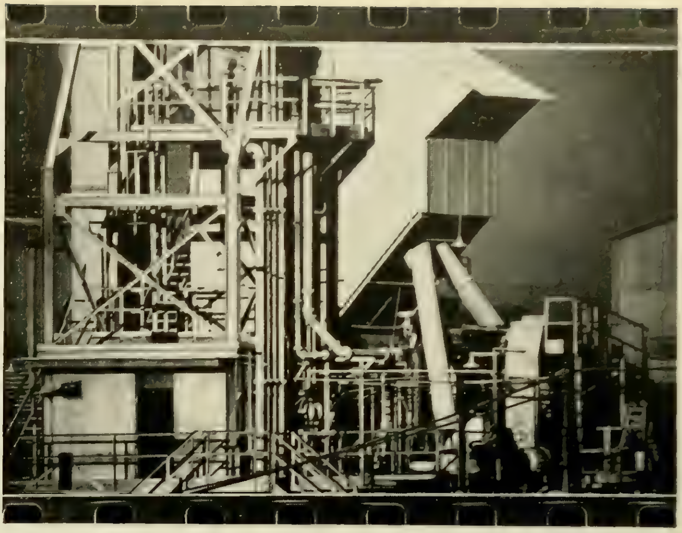
During discussions of the IHD program at UNESCO House in Paris, many of the 150 delegates spoke spiritedly of the need to provide education and training for hydrologists and technicians—an essential segment of the program. One realist remarked that this fine talk was encouraging but added that the program will require education of another kind, coupled with loosening of governmental purse strings. What provision will UNESCO make for the education of presidents and kings, of members of parliaments and ministers of finance?

In reality, that sort of education is one of the prime objectives of the IHD. Water and water problems, it has been agreed, must be placed squarely before the public and governmental eye throughout the world in order to establish the sobering fact that man's future success on this planet may well hinge largely on his ability to manage water effectively. This ability will be closely tied to scientific understanding of water. In turn, the ability of science to advance human well-being in any nation depends on whether the government of that nation recognizes the importance of science in its national economy, provides adequate resources for the advancement of science and technology, and actually uses the available scientific and technical knowledge.

Some of my colleagues at home and abroad have raised the question whether the poor and undeveloped countries really can contribute to an international scientific program. This question sounds supercilious. We must remember several things about science: (1) Contrary to widespread misconceptions even among scientists, who ought to pay more attention to history, science is thousands of years old. Only "Big Science" is new. Nations that are only now emerging literally from the Stone Age can contribute to science, just as they contribute to the sum of human culture. (2) Science is not magic; it is hard work. In an age when any minor discovery may be heralded as a "break-through," it is important to realize that human progress is based not only on the ostensibly single-handed, spectacular achievements of a few publicized individuals but also on the dedicated service of many obscure individuals, unhonored and unrecognized, who do the countless little tasks that make the spectaculars possible. (3) The results of science are accumulative, and its breadth and usefulness grow continually. One can contribute to science by using it, as well as by studying it and seeking new principles. (4) Any intelligent and diligent person can contribute to science, and all populations include intelligent and diligent people. Both attributes are essential, because intelligence without diligence generally is fruitless, and diligence without intelligence is blind.

Human knowledge and ingenuity are adequate to make considerable alterations in the physical world. Many alterations that have been made have been ill-advised, perhaps reckless, but that is because at most places modern men have combated the forces of nature, rather than learned to work with those forces to reach desirable and attainable ends. This is true of all countries, and merely bespeaks the fact that available knowledge of the physical world is greater than is being generally used.

People who ought to know say that it is not only conceivable but actually possible to abolish famine and to control



*We print the sprocket holes here to show exactly what the Questar Field Model below impressed on the Tri-X negative. Time, 1/500 second. Normal development with D-76. Some of the background buildings are partially obscured by smoke.*

This photograph was taken with a Questar telescope. We think no other instrument could show such sharp detail.

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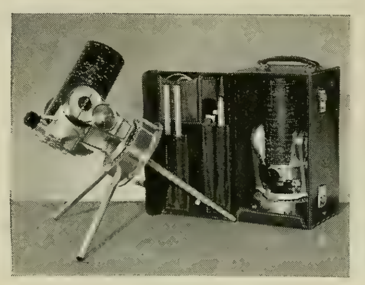

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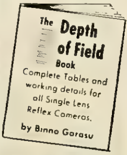
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Dr. Nace, research hydrologist with the Geological Survey of the U.S. Department of the Interior, has been recently appointed by the National Academy of Sciences as chairman of its U.S. National Committee for the International Hydrological Decade.

disease, both of which are closely tied to water problems. But science cannot do it alone. These are problems of human societies that cannot be pushed in superimposed, intellectually chosen directions. Strong social forces often are decisive, and the physical scientist often is socially powerless. In the final analysis, water problems are human problems, and physical science cannot solve human problems; it can solve only scientific ones. At the same time, science can—at the very least—provide a sound basis from which receptive humans can approach their problems.

Co-operation implies reciprocal understanding and agreement. In most human activities, especially on the ideological and other social planes, understanding and agreement are difficult to achieve because there is always room for difference of opinion and argument. The principles of science are based on experiments that can be repeated and verified, so there is less room for argument than in other activities and even, *mirabile dictu*, less danger of emotional involvement. A scientific program, therefore, can contribute much to international understanding. A principal shortcoming of the peoples of the world is their limited ability to co-operate and plan. This ability, however, is much greater on the scientific plane than on the social one, as has been demonstrated by every international scientific program ever undertaken.

Science is intrinsically international because a scientific principle is a universal truth. The idea for an International Hydrological Decade arose among men who recognize that science has plenty of room for advancement. At the same time, scientists need more social consciousness and must contribute more directly to human welfare. Investment in science is an investment in man, because science is man-made. It is an investment in a better world.

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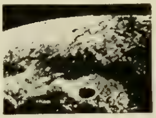

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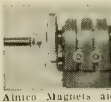

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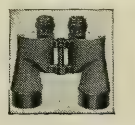

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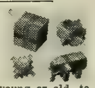

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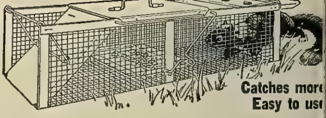

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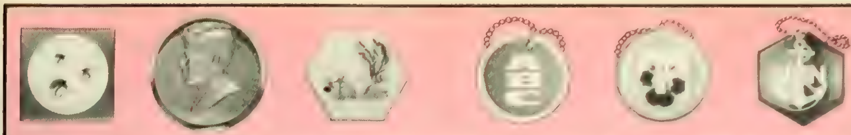

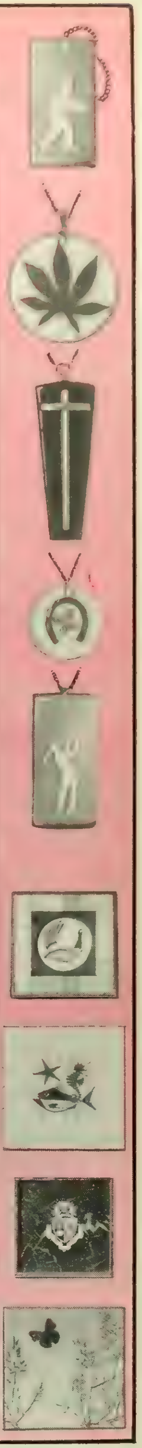

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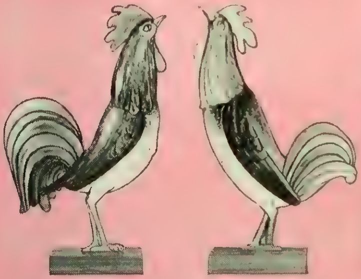

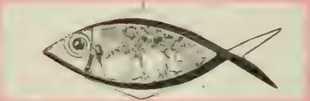

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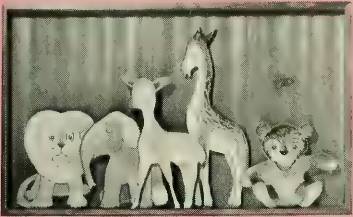

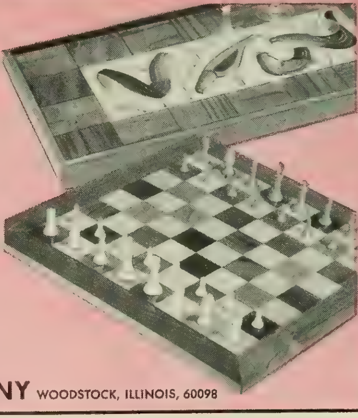

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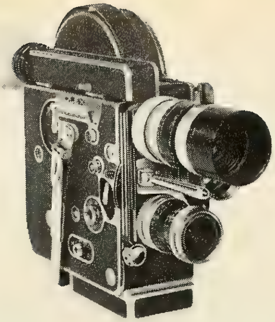

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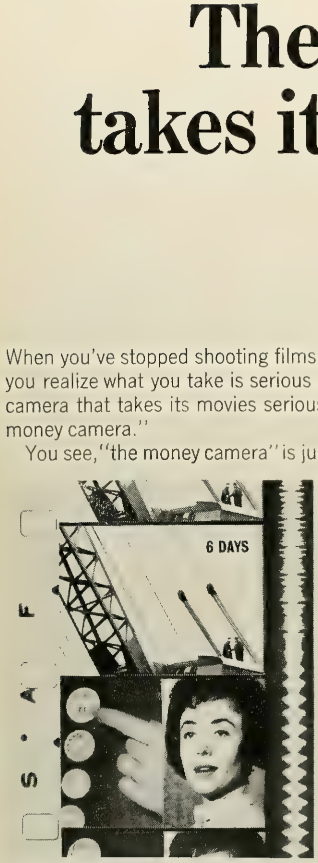

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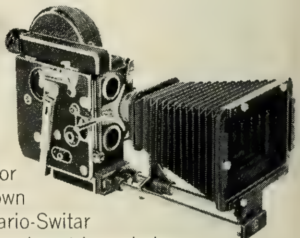

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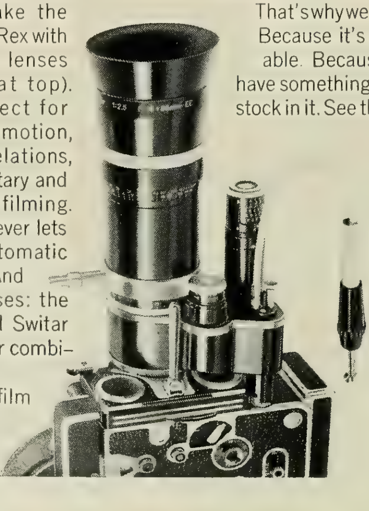

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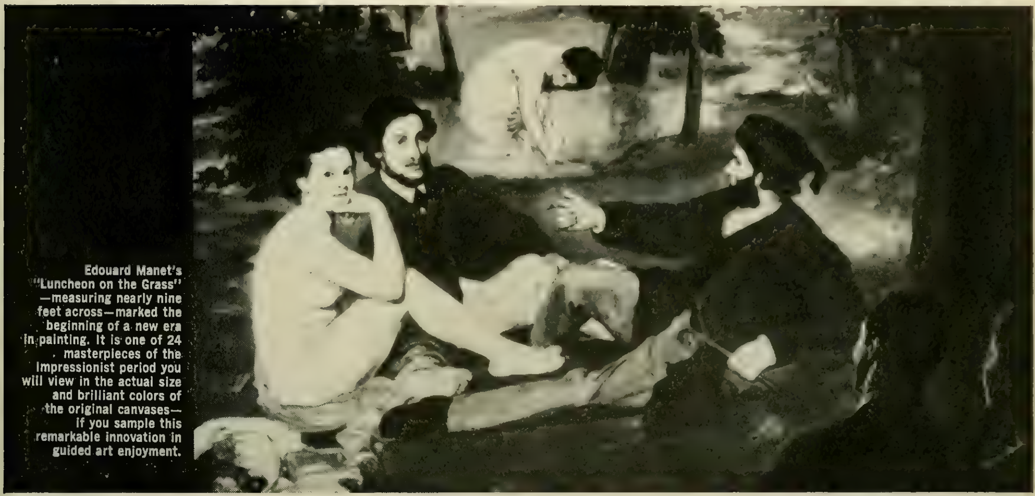

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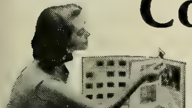

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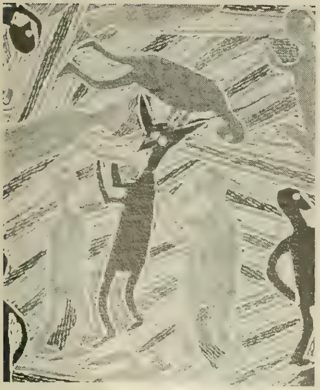

COVER: Bark paintings from Australia, strips of flattened eucalyptus painted with ground ochers, are among the many interesting features of aboriginal art. Often prepared for use in clan ceremonies, the panels relate local narratives and portray mythological scenes. The detail on the cover was taken from a work by the artist Madaman who is from Yirrkala, a section of Arnhem Land on the north-central coast of Australia. It depicts a group rite or dance involving both men and animals. Other paintings, also from Yirrkala, illustrate the article on pages 46-53 written by the late Dr. Stuart Scougall and Philip C. Gifford.

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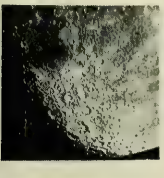

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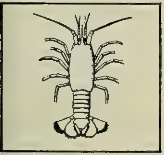

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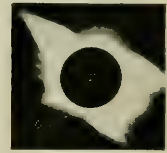

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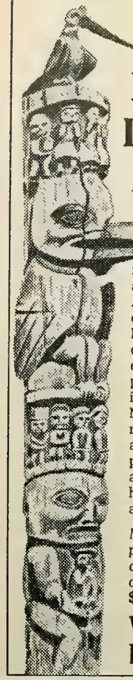

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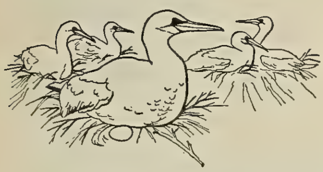

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# Perspectives in biology

### By Jane Oppenheimer

THE EVOLUTION OF BIOLOGY, by M. J. Sirks and Conway Zirkle. *The Ronald Press Co., $6.00; 376 pp., illus.* OVERTURES TO BIOLOGY, by Philip C. Ritterbush. *Yale University Press, $7.50; 287 pp., illus.* REVOLUTION IN BIOLOGY, by John Maddox. *The Macmillan Co., $5.00; 179 pp., illus.* THE MYSTERY OF PHYSICAL LIFE, by E. L. Grant Watson. *Abelard-Schuman, $3.95; 156 pp., illus.*

WHEN I was a graduate student in the early 1930's, my research adviser suggested I study the history of my specialty—experimental embryology—and, accordingly, a third of my doctor's dissertation was published in a technical journal devoted to the history of science. This was then an oddity for a zoological dissertation, and the chairman of my department did not wholly approve, saying that the study of the history of science should wait for a scientist's retirement from the laboratory, and his was the prevailing opinion at the time.

Today, thirty years later, the same differences of opinion obtain. Some overconfident young men believe that nothing is important that was written more than ten years ago; so they tell their students, and so their students believe. Perhaps they have some justice on their side, especially if they are working in fields where work in other laboratories may outdate their own publications before they even appear in print. On the other hand, interest in history has become respectable for those in their preretirement years who choose to think of their work in a broad perspective, and, in fact, historical studies by young men trained in the technical methods of history are, in general, far superior to the diffuse writings produced a generation ago by amateurs. The history of science is now a scientific discipline in its own right, even to the extent that the National Science Foundation and the National Institutes of Health give financial support for historical studies, considering them as advancing scientific welfare.

The books reviewed here exemplify four entirely different approaches to the history of biology. There are more than four ways to view history—there are as many as there are individuals who follow them—but a description of these books may illustrate some of the characteristics of scientific history as practiced today, and some of the relationships of history to modern biology.

*The Evolution of Biology*, by Sirks and Zirkle, is the most comprehensive of the four in its intent and content. It discusses the history of biology from the time of its prehistoric inceptions to the period of molecular genetics. A book that covers biology up to the Renaissance in 115 pages and biology after the Renaissance in 235 pages can hardly be all-inclusive, and the authors have not attempted to make it so. It does present, however, a coherent account of selected discoveries in biology and of the formulation of concepts important for biology today, and it shows how biology has changed. *The Evolution of Biology* would be useful reading for advanced high school students or for college students, as well as for general readers interested in biology. It is documented by long bibliographies and parenthetical references in the text.

Ritterbush's *Overtures to Biology* is subtitled "The Speculations of Eighteenth-Century Naturalists," and he has confined himself to a more circumscribed period of time and to a more limited theme than have Sirks and Zirkle. His book describes and analyzes the speculative thought from which biology as an experimental science was later to emerge; Ritterbush would not classify much of the work covered by Sirks and Zirkle as biology. He holds that biology became an experimental science as we know it only at the turn of the eighteenth into the nineteenth century. From among the many speculative themes current in the eighteenth century he discusses only two: first, the rôle of electricity and subtle fluids as explanatory of physical and vital phenomena; second, analogy between animals and plants as explanatory of vital phenomena in plants. His book is replete with quotations; there are numerous footnotes on nearly every page, and there is a long bibliography. The book thus is written in a scholarly fashion, but this does not diminish its value for readers with less technical training than the author. The material he has chosen to discuss is of consuming interest, and he has presented it delightfully and with humor. It is, therefore, good reading for both professional biologists and historians, and is recommended as a supplement for those who are introducing themselves to biological history by reading books such as *The Evolution of Biology*. It will enable them to discover the kind of evidence that

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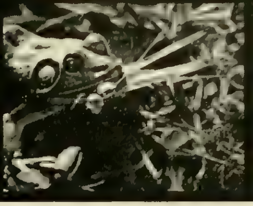
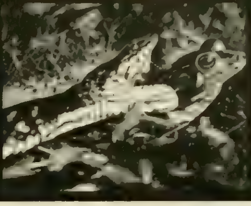


2. A bullfrog captures and eats the dragonfly.



3. A water snake surprises the frog and swallows it whole.

4. A hawk flies off with the snake ... end of a food chain.

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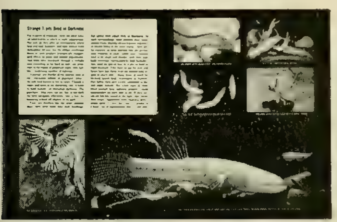

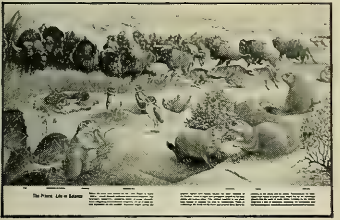

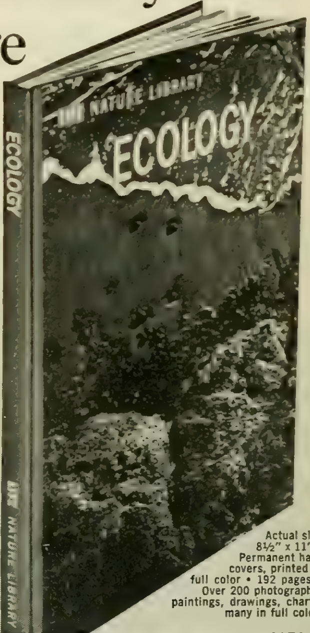

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serves as the basis for the generalizations found in textbooks.

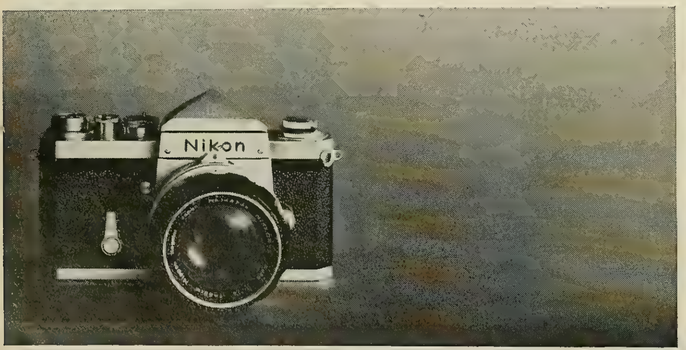
Maddox' book, *Revolution in Biology*, is also confined to a subject limited in time and scope. The revolution to which the title refers is the development of molecular biology, a discipline the author says began in 1953 with its first major success—the theory, developed by Watson and Crick, of the arrangement of DNA molecules in the living cell and their influence on outstanding features of heredity. (Not all biologists or historians agree with this interpretation.) The principal subject of his discussion is the progress made by molecular biology during the past ten years or so. It is thus a chapter in very recent history. *Revolution in Biology* might well serve as an extended interpretation of sections found at the end of *Evolution in Biology*. It is written in a highly journalistic style, and there is no documentation whatsoever to intrude between the book and the readers—or to lead them to additional reading should they desire to explore further.

The history of science is never completely separable from philosophy, since scientific ideas are born in contexts wider than those of science itself. In medieval days it would have been more difficult than it is today to explain life in mechanistic terms, but during all periods of history some individual thinkers have explained vital phenomena to themselves in vitalistic terms, others in more materialistic ones. Maddox, like many contemporary molecular biologists, presents a mechanistic interpretation of life.

*The Mystery of Physical Life*, by E. L. Grant Watson reads like the work of a Jungian mystic who does not participate in the materialistic interpretation of biological facts. Unfortunately, it does not express its vitalistic opinions very well: it is repetitive and garrulous in style and makes some egregious errors of scientific fact. It does demonstrate that mysticism in science is still alive in the 1960's; this may be its chief value.

One advantage of reading histories of science is the revelation that scientific facts are not always viewed in the same light and that interpretations of these facts have differed throughout the ages. It is through attempts to resolve differences that the sciences progress; thus, attention to history presents major insights into the workings of science as it is practiced today.

*Dr. Oppenheimer is Professor of Biology at Bryn Mawr College. Among her major interests are experimental embryology and the history of biology and medicine.*



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THE ETERNAL PRESENT: VOLUME II, THE BEGINNINGS OF ARCHITECTURE, by S. Giedion. Bollingen Series 35, *Pantheon Books, $12.50; 583 pp., illus.*

STRANGE it is, but in some ways ancient man was more reasonable than his space-age counterpart. Five thousand years ago man was already impatient with accumulating descriptive facts, for he must have known from past experience (he was, already, about one-half million years old) that data gathering and collating would not provide the answers to the most profound questions posed by human existence. Why, the Sumerian and Egyptian asked, should the sun travel an appointed course through the heavens, bringing alluvial plain and river delta to flower and fruit? Compared to this searching for first causes, the question of the mechanics of the journey or the geology of the traveler was hardly worth determining. To simplify matters, the Egyptian put the sun in a boat to make its daily round. We know the boat is a fiction, that the earth spins around the sun, but does this simple fact tell us more about the meaning of the journey than a solar barge?

For the thinkers of antiquity the world was organized on reasonable principles even though their effect upon man was frequently perplexing, frustrating, and deeply tragic. The ancients attempted to grasp these cosmic governing forces by the use of a technique which we, in an uneasy world that uses scientific technique, call the mythopoeic. They gave form and life to the abstract and symbolized it in the disciplines of their cultures; their sacred architecture was one of their most significant modes of symbolic expression. The Swiss cultural historian Giedion attempts to demonstrate in this volume how ancient cultures sought to bring themselves into alignment with the cosmos through their monuments and buildings.

In this second volume of a two-part inquiry into the mind and art of ancient man, Giedion concentrates on the first great organized societies that flourished along the banks of the Tigris, Euphrates, and Nile. The first volume (*see* NATURAL HISTORY, February, 1964) began the story with an analysis of prehistoric man's reaction to the world in which he found himself and a detailed description of his earliest attempts to come to terms with an environment of which he was a cognitive part. Hence, while a common theme relates the two volumes, they also may be read independently.

The book is a model of quality production (a Bollingen hallmark), with more than three hundred excellent photographs and drawings carefully co-ordinated with the text, which reduces page flipping to a minimum. In addition, there are eighteen well-printed color illustrations, clear maps, a sizable reading list for the reader who wants to go on to more technical studies, and two indexes. This high standard of bookmaking compensates for the price and makes the volume a handsome addition to a personal library.

Several years ago, in his *Space, Time, and Architecture*, Giedion investigated the architecture of the modern world in order to demonstrate how the forms we give our buildings reflect the shapes of our culture. Now, he concentrates on the architecture of the Sumerians and the Egyptians, for it is with the emergence of these riverine cultures that he finds the first beginnings of diversified and monumental architecture, hence, the subtitle of the volume. A fair part of the book contains discussion of sculpture, because this art form was of first importance in ancient architectural programing (and, also, the author views architecture as sculpture with interior space). But the greater portion of the book deals with architecture not only as an art form but more importantly as an expressive and enlightening symbolization of the inner life of its creators. Behind this particular story, however, Giedion's basic thesis is ever-present: that one can find in the history of man significant elements of constancy running through the millenniums of change.

Giedion's writing style is clear and didactic. First, he provides a brief synopsis of the facts and historical position of the particular monument, building, or site under discussion. He borrows freely from the technical archeological reports, summarizing the findings and conclusions of the excavators. Then, he proceeds to his theoretical interpretations and synthesis. He is clearly most at home in the field of architectural analysis. Certainly his signal contributions are his perception and keen intuition that permit him to reconstruct the quality and character of a building, which, as his photographs so often show, present to the eye little more than a scattering of badly shattered fragments partly buried in the encroaching desert sands and scrub.

A sample of the broad concepts treated by Giedion will provide a better picture of the texture and substance than a dry listing of the volume's contents. The author emphasizes ancient man's attitude that the purposefulness of natural phenomena springs from its being the physical manifestation of the metaphysical cosmos. Like modern man, ancient man constructed models to help him visualize and make concrete the purely conceptual world. As the modern mathematician uses a band of paper with a single twist to illustrate the concept of a surface, so also the ancient theologian used the dung beetle as a physical expression of the solar force. The dynamic aspects of the sun, its changing role in the daily journey, were symbolized by the Egyptians in terms of different models: the awakening sun was the scarab, the burning midday sun became the soaring falcon, and the sun in its nightly circuit of the underworld took on the form of the ram. But the sky was visualized as the overarching body of a goddess; hence, the solar barge had to travel through her, entering as a generative force, leaving as an eternal symbol of the reborn day.

The use of animals to symbolize cosmic forces is viewed by the author as a continuation of Paleolithic man's deification of the animal, the thesis he argued in his first volume. In the Old Stone Age man assumed a role subordinate to the magnificent beasts he drew on cave walls because they were endowed with a beauty of strength and skill that he lacked. Thus animals first held a divine place in man's cosmogony. Later, man separated animal from divine; the animal could be a symbol for the divine, but not the godhead. During the age of the great cities in Mesopotamia and Egypt, says Giedion, man for the first time saw the beauty of human form and accepted it as superior to that of other animals; with this discovery came the complete anthropomorphism of the gods. The universe had moved from the zoocentric to the anthropocentric until, finally, with the triumph of Christianity, the animal was reduced to a despised creature. Such basic considerations as these, the author holds, are fundamental to our understanding of the formative periods of architectural theory.

For Giedion, the pillared temples, mountain-shaped ziggurats, geometrical pyramids, and chambered shrines are more than houses of cult mysteries and of the dead. More important, they are the concrete embodiment of these metaphysics and philosophies of life. Thus, his depth analyses of architecture. Why bother to look at the monuments of the past and keep them in mind? Giedion does so "not so much to record the facts as to strengthen belief in the power of human imagination." Giedion, a thoroughgoing humanist, is, after all, enthralled with man.

BERNARD GOLDMAN
*Wayne State University*

BIRDS OF THE NEW YORK AREA, by John Bull. *Harper & Row, $8.95; 540 pp., illus.*

THE two basic accouterments of bird watchers nearly everywhere are their binoculars and Peterson Field Guides. The odds are strong that most birding enthusiasts in and about New York City will soon avail themselves of still a third item—if they have not already done so—a copy of Bull's *Birds of the New York Area.* A knowledge of where and when

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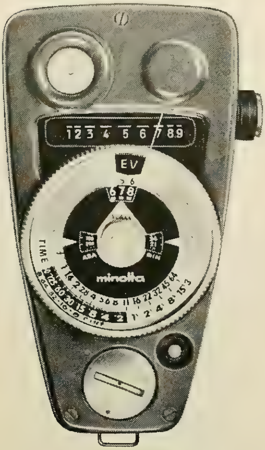

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to find birds can be a valuable aid in field identification. But John Bull's book is far more than a guide to finding birds around New York. It is a scholarly and authoritative compilation and condensation of what is currently known about the spatial and temporal distribution of the birds of the area, with emphasis on the vast amount of data that has accumulated since the publication of the last regional treatise (*Birds Around New York City*, by Allan D. Cruickshank, 1942). Bull's book includes records through the breeding season of 1962, plus some noteworthy additions through December, 1963.

The main section of this book is devoted to accounts of the 404 species of birds whose presence in the region is supported by specimens, colored photographs, or creditable sight reports. The usual treatment for these "regulars" includes the range of the species, relative abundance and status in the New York area, frequency of observation, migration dates, egg dates, and general remarks on breeding ecology. Extra care has been taken to determine the authenticity of claims of the breeding status of certain species, and to document the significant changes in distribution that have occurred during the past two decades. Most accounts are one page or less in length, although several pages are devoted to species presenting special field problems (Traill's Flycatcher) or having exceptional local histories (House Finch). There are no photographs or plates, as in previous New York guides, but a number of line drawings by Cornelius J. Ward are used effectively as chapter headings. Twenty regional maps depict the isolated breeding localities for a few southern species (Prothonotary Warbler), northern species (Brown Creeper), and colonial water birds (Black Skimmer). A list of "escapes" includes eight species of questionable origin; some have undoubtedly escaped from, or been released by, aviculturists. An additional nineteen species appear on a "hypothetical" list for want of satisfactory evidence.

Beginning students may regret the omission of certain features that proved effective and popular in Cruickshank's book, such as the tables of species to be expected in various types of habitat and the month-by-month account of "the ornithological year." The author's discussion of good birding localities and the gazetteer would have been more effective had they been keyed to the excellent map of the New York area. Serious students, on the other hand, will welcome the addition of a fine bibliography of the principal publications relating to the birds of the region.

Attrition and alteration of habitats, creation of refuges and parks, an ameliorating climate, urbanization, misuse of toxic chemicals, introductions of extralimital species—these are only some of the many factors that have contributed to the instability of bird populations in and about the great metropolis and have created the need for this work. Equally dramatic and demonstrable changes can be expected during the next two decades. John Bull's book sets a high standard for amateurs and professionals in their future efforts to document and interpret this dynamic aspect of our avifauna for the next generation of bird watchers.

WESLEY E. LANYON
*The American Museum*

A FIELD GUIDE TO THE STARS AND PLANETS, by Donald H. Menzel. *Houghton Mifflin Co., $4.95; 397 pp., illus.*

DONALD H. MENZEL, Director of the Harvard College Observatory, makes a significant contribution to the famous, ubiquitous Peterson Field Guide Series with his *A Field Guide to the Stars and Planets*. A tremendous amount of information and directions are packed within these small-format pages. Forty-eight white-on-black star maps delineate the sky throughout the year. Each map is made of two sections—one shows the stars to magnitude 4.55 with connecting lines to emphasize the constellations, the second shows the same sky without lines, more as it actually appears.

A distinctive feature of this useful volume is the photographic atlas charts from the Harvard Observatory. Below magnitude 4.55 the number of stars increases so rapidly you cannot draw charts of them. Dr. Menzel shows a diagram of a section of the sky on the left-hand page and a photograph of that section on the right. Fifty-four such charts provide a fine view of the entire sky and clues to help the amateur armed with binoculars or telescope in finding the stars himself.

A dozen moon maps show surface features well; opposite each is a chart naming the features. In addition, the reader learns of ways to observe the sun; to locate the planets at any time; to observe meteors and comets; to photograph celestial objects and phenomena; to locate, observe, and recognize double stars, variable stars, nebulae and galaxies, and to understand time relationships.

A wealth of information, including a glossary of terms, references, and extensive data, is contained in more than fifty pages of appendixes.

Altogether, Dr. Menzel's field guide is required for the amateur who has gone beyond unaided viewing and the mere identification and location of constellations. It should be used by anyone ready for the more challenging aspects of sky watching.

FRANKLYN M. BRANLEY
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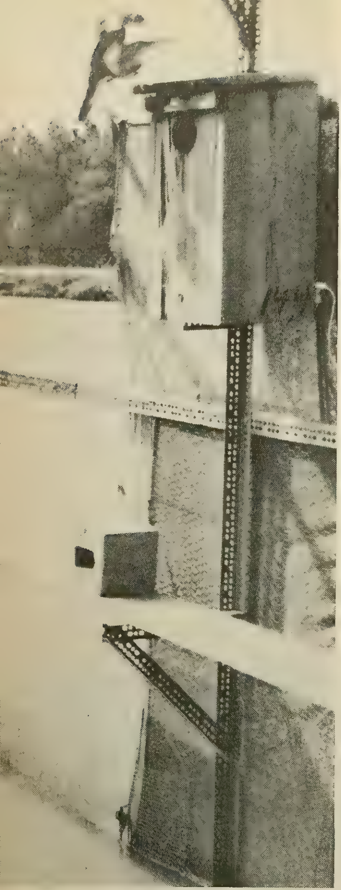


**Hole-nesting Wood Duck** nears nest box inside large nesting pen.

# Components of Recognition in Ducklings

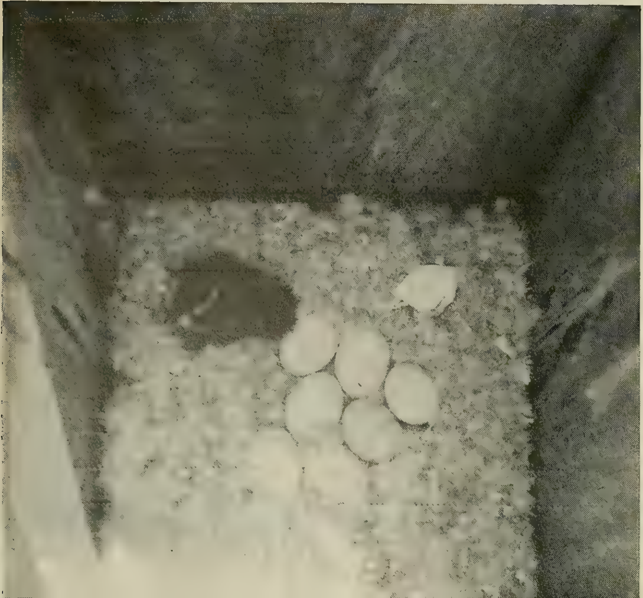
## Auditory cues help develop familial bond

By Gilbert Gottlieb

During the past fourteen years, well over a hundred research articles have reported laboratory studies of the "following-response" and "imprinting" in young precocial (nidifugous) birds. Such animals (ducks, geese, swans, chickens, turkeys, quail) can locomote shortly after they are born, and it has been found that, independent of feeding or other conventional "rewards," they quickly attach themselves to the first moving (or otherwise conspicuous) object that they encounter visually after hatching. The laboratory-reared bird responds to the object much as it would respond to its parent in nature—it follows or otherwise stays close to the object and prefers contact with the first such object over other dissimilar objects to which it is later exposed.

Naïve young birds deprived of contact with their own parent will behave in a filial manner toward objects that do not bear the slightest resemblance to their own species. This behavior prompted the hypothesis that species recognition in precocial birds must be a function of early learning. Specifically, it has been suggested by Konrad Z. Lorenz that precocial birds come to recognize their own species as a generalization from experience with their parents shortly after hatching. Thus, the theoretical crux of the perceptual side of imprinting is that species recognition derives from early experience with the actual parent or some surrogate that the newly hatched animal accepts as its parent on the basis of early contact. It is known, for example, that birds deprived of contact with their own species and reared, say, by humans develop a fondness for humans that in some instances precludes later social intercourse with their own species.

Most of the research on imprinting and the following-response has been concerned with the behavior of ducklings and chicks hatched in incubators in the laboratory. The present report, however, is a distilled account

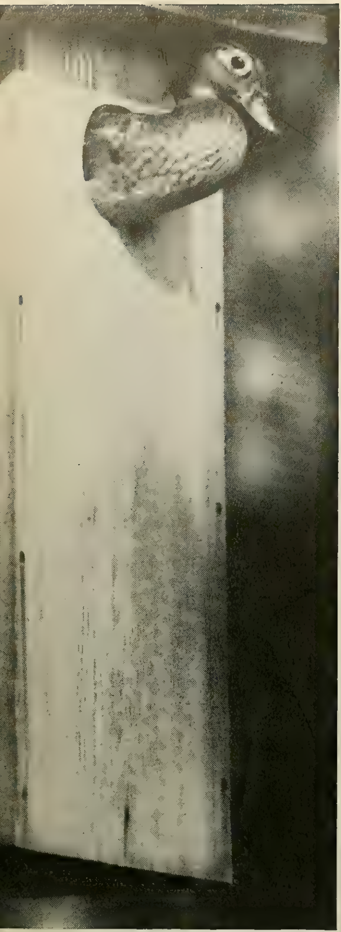


**Young Wood Duck,** just hatched, was photographed after parent was flushed.

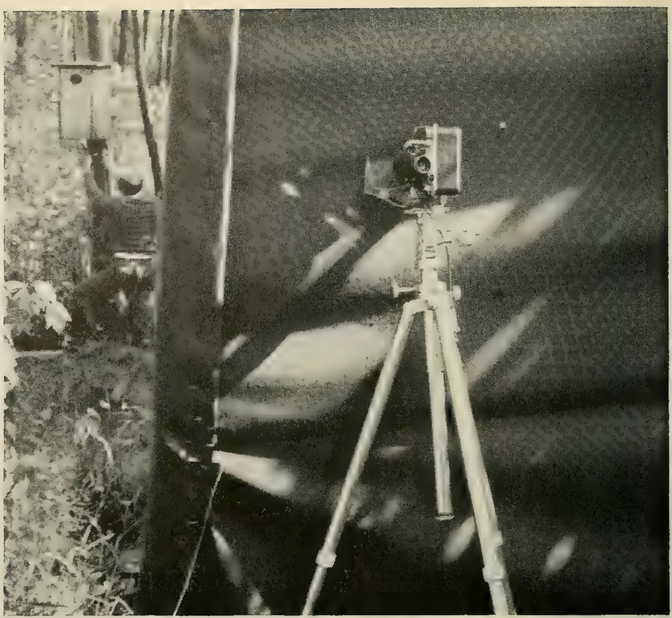
**Incubating Mallard**, a ground nester, will remain with her young after they hatch until she instigates the exodus from the nest. During the 24- to 48-hour period, auditory stimulation plays a notable role in the parent–young bond.

of field observations made at our research station near Dorothea Dix Hospital in Raleigh, North Carolina, over the past four years. It deals with the rapid development of the social bond between ducklings and their parents in nature. The report concerns mainly the behavior of two species of ducklings preceding and during their exodus from the nesting cavity.

Among the ducks, there are two nesting types—the hole nesters and the ground nesters. The two species we have studied most intensively are the hole-nesting Wood Duck (*Aix sponsa*) and the ground-nesting Mallard (*Anas platyrhynchos*). Wood Ducks hatch out at the base of deep, vertical cavities in dead and decaying trees, where low illumination prohibits the significant operation of vision during the period prior to the departure from the nest. In the Mallard, on the other hand, vision might be more important, as the Mallard ducklings can see their mother as soon as she walks off the ground nest. Due to these differences in nesting conditions in the two species, it was anticipated that the hole-nesting ducklings might possibly be more dependent upon auditory stimulation than upon visual stimulation from the parent, while the reverse situation might hold for the ground-nesting birds. As it turned out, however, the research findings indicated



**Wood Duck hen** will not lead young from nest box if she senses danger, *left.*



**Camera** is obscured from ducks by the blind. Microphone is hidden under nest.

that auditory stimulation from the parent is of prime importance in *both* nesting types.

For our field studies, we erected some nest boxes high in trees and on posts above both land and water, and placed others directly on the ground. The entrances to the Mallard nesting boxes were made two times the size of the entrances to the Wood Duck nesting boxes. (The oval entrance to the Wood Duck nesting boxes is 4 inches wide and $3\frac{1}{4}$ inches high.) In addition, the hole of the Mallard nest box is situated close to the bottom of the box, while the hole of the Wood Duck nesting box is located near the top, allowing a deep nesting cavity.

As it turned out, Wood Ducks always used the aerial nest boxes, while Mallard hens always nested in the boxes on the ground. We never saw a Wood Duck enter a ground nest nor did we observe a Mallard hen inspecting an aerial nest.

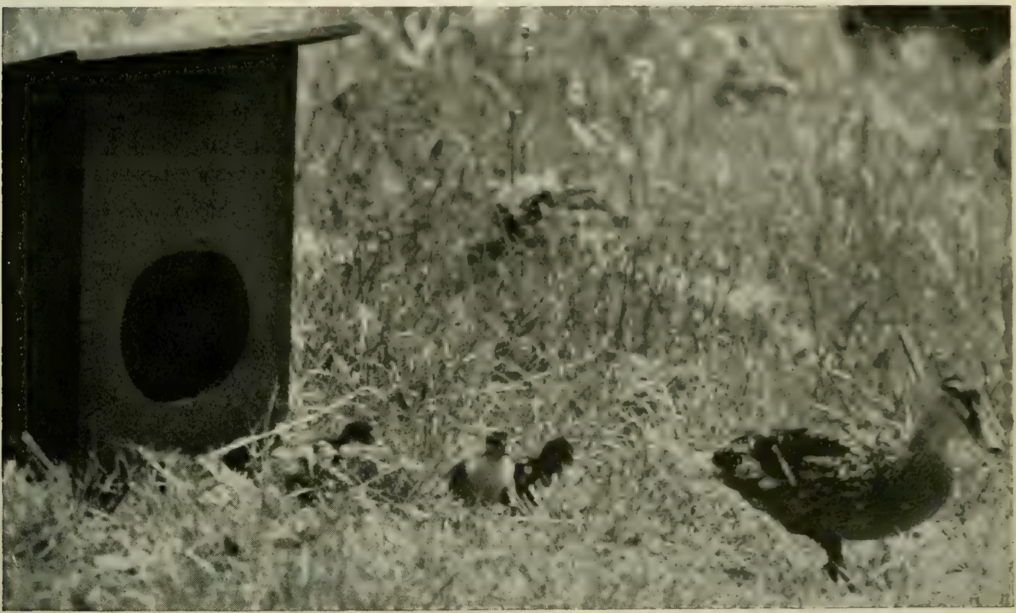
Under typical circumstances, our method of observing the development of the familial bond in these ducks has been to place our recording equipment and cameras in an observation blind as far from the nest as feasible. A highly sensitive microphone is concealed near the nest, and a transistorized recording machine is in the blind, so we can monitor the activities within the nest box without disturbing the hen and her brood. The magnetic recording tapes thus obtained form a permanent record and are available for subsequent laboratory analysis by oscillographic, spectrographic, and other techniques of audio analysis.

We begin our observations several days before the eggs are due to hatch. (The incubation period is 30 to 33 days in the Wood Duck and 25 to 28 days in the Mallard.) Our vigil begins shortly before sunrise and ends shortly after sunset, as the hen never initiates the exodus during darkness. We are interested in the kind and amount of vocal activity between the ducklings and their parent as the eggs begin to pip and the young emerge.

The exodus takes place between one and two days after the young hatch, during which time the young—sometimes as many as twenty—stay beneath the hen receiving food from yolk sacs. The mother does not leave the nest box during this period, unless she is flushed. (If she *does* leave for some reason, she will not utter the exodus call.) It is important to emphasize that in making field observations such as these, it is essential that the observer take great care lest he alert the birds to his presence and thereby distort the "typical" procession of events by heightening the natural wariness of the birds or by frightening them.

The new (and unanticipated) information that our field studies have provided is that in both hole- and ground-nesting species the hen begins uttering its exodus call long before it leads the brood from the nest. In this way the young have an opportunity to learn the individual characteristics of their parent's call before they leave the nest (that is, before they can see their parent, as it is dark inside the Wood Duck's nest and both species are covered by the body of the mother). In the first graph on page 16, which presents information from a repre-

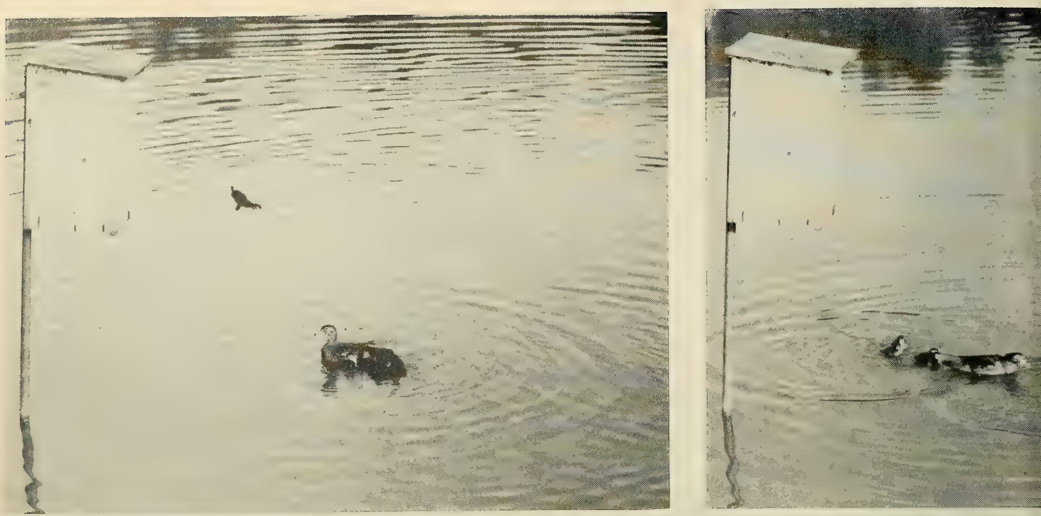
**Mallard hen** can be seen inside ground nest box, *above*, before beginning the exodus. Outside the nest box, *right*, she utters a low-intensity call and then leads brood toward the water, *below*. In their early recognition of parent, the ducklings respond primarily to auditory, not visual, cues.



sentative duck of each species, it can be seen (1) that the maternal Wood Duck begins to vocalize somewhat earlier than does the Mallard; (2) that the Wood Duck utters her call more frequently than does the maternal Mallard; and (3) that in both species the rate of maternal calling increases throughout the entire pre-exodus period, reaching a peak during the exodus itself.

No qualitative change is discernible in either maternal call at any stage. To the human observer the basic call of the maternal Wood Duck sounds like "kuk," while the call of the maternal Mallard sounds more like "hut." A waveband analysis of the two calls indicates their audiometric similarity (*see graph on page 16*). Within each species, there are small differences in the rate, pitch, and/or rhythm of the individual maternal calls. Between the two species, however, these differences are much greater. The difference in the rate with which the calls are uttered by the respective ducks contributes a great deal to the *perceptual* dissimilarity of the two calls (at least for the human observer).

The gradual buildup in the rate of maternal calling during the various stages leading to the exodus points to the reciprocal stimulative interplay between the hen and her brood during the pre-exodus period. That is, as the ducklings become more active inside the nest box, the hen's vocal rate increases. This is succeeded in turn by an increase in the vocal and motor excitement of the young, and so on, reciprocally, until eventually (it is

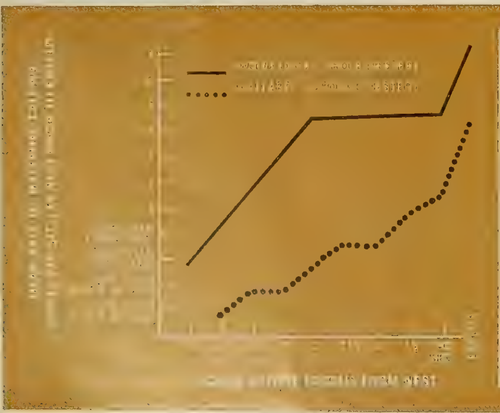


**Duckling** drops out of the nest box in answer to maternal Wood Duck call. The young quickly climb the interior wall of nesting cavity to reach the high exit hole, and most of the ducklings are out within minutes. In the photograph above,

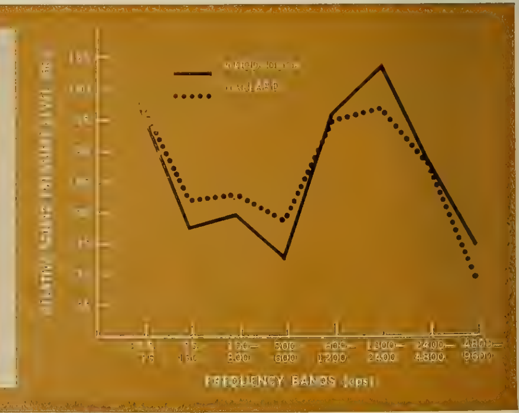
my guess) the ducklings' over-all level of activity stimulates the hen to leave the nest box and instigate the exodus.

Another feature of the gradual increase in the rate of the maternal call during the pre-exodus period is that such a change in rate of auditory stimulation obviates the possibility that the young might habituate to the call of the parent and not respond to it during the exodus. In the laboratory, for example, we have exposed young domestic Mallards to a recording of the high-rate exodus call before testing and have found it has the effect of depressing their responsiveness to it during the test, as compared to the performance of a control group that was not exposed to the parental call at all before testing. That is, the control group followed the calling model more persistently than the experimental group. "Testing" simply involves the placement of an incubator-hatched duckling inside an apparatus where the bird has the opportunity to follow a model emitting the parental call or some other call. (See photographs on page 19 for one example of testing.) Whether or not the animal follows the model emitting the parental call and the persistence with which it follows the model are the usual objective measures of the bird's responsiveness to auditory stimulation under experimental conditions.

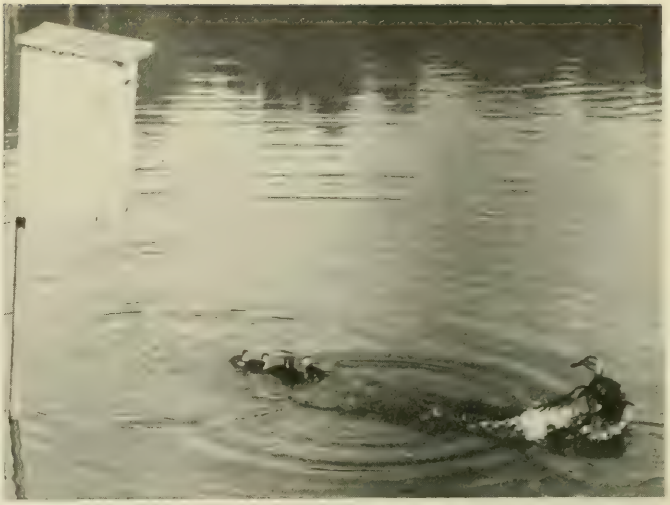
The exodus in the ground-nesting species, the Mallard, is made to the accompaniment of visual as well as vocal stimulation. The ducklings, on the same level as the hen after she has left the nest, can see their parent as she calls to them. The young Wood Ducks, on the other hand, inside a deep nest high above the ground or the water, cannot see their mother after she has left the nest and must respond



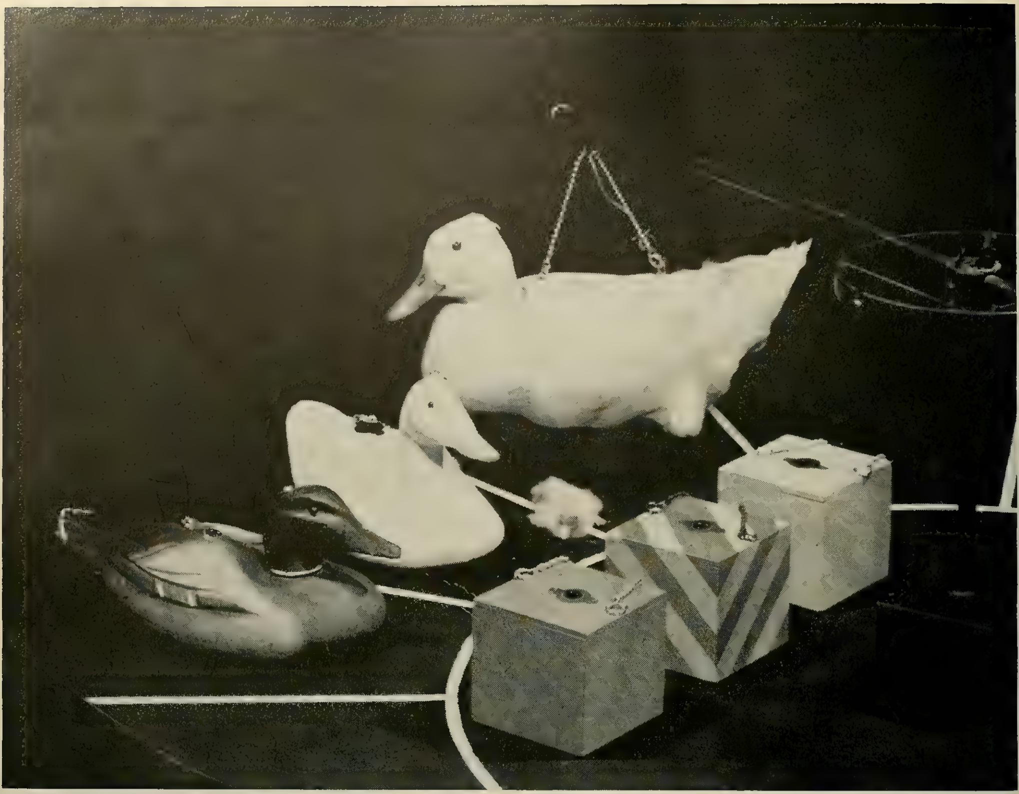
**Rate** of parental calls increases as the time for the exodus nears. Graph compares rates for Wood Ducks and Mallards.



**Waveband** analysis of the two exodus calls shows their respective pitch frequencies and their relative loudness.



hen prepares to strike Mallard that has approached during the exodus. Attack takes place at right; note last duckling perched in the exit hole. When the intruder has left and the exodus is complete, *below*, hen leads her brood into swamp.



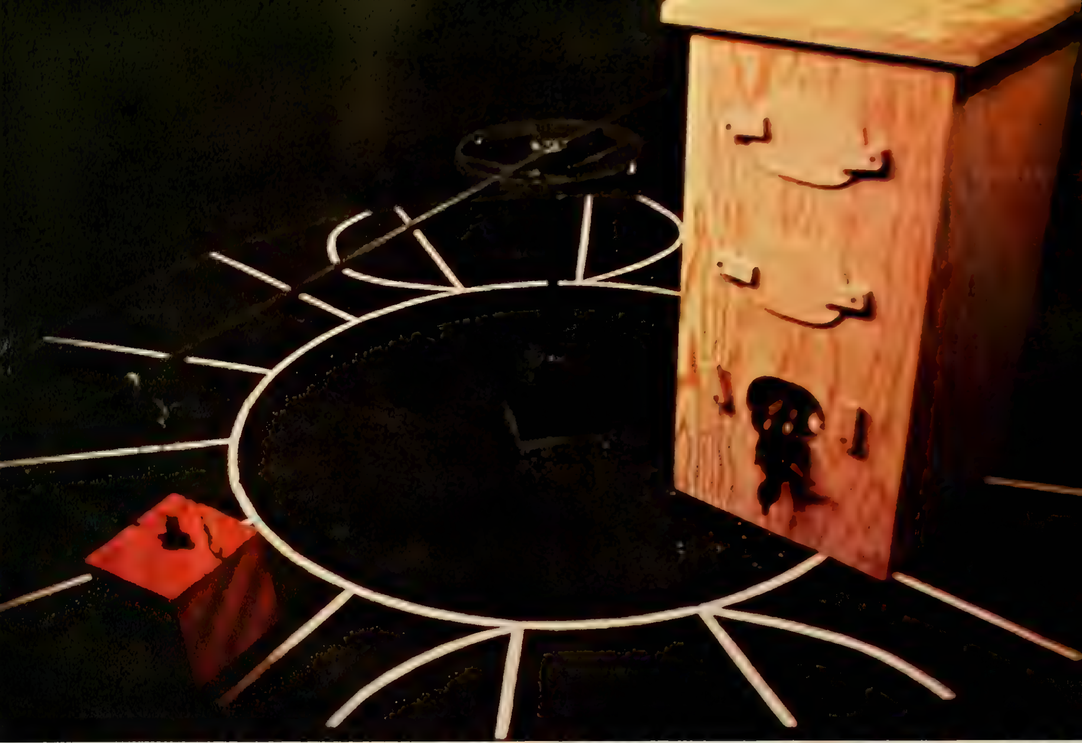
**Visual stimulus objects, including duck models, surround a small Peking duckling. In laboratory, incubator-hatched ducklings respond with greater specificity to recordings of the parental call than to visual properties of parent.**

initially only to the parental call. (In the laboratory, we have found that both Mallards and Wood Ducks will respond to a recording of the parental exodus call. The Mallards, however, are more likely to climb out of a nest box when they can connect the call with some visual object, such as a moving striped box.) Both hens make a reconnaissance of the area before instigating the exodus, and will delay the exodus if they sense intruders. The photographs on page 17 show a Wood Duck hen attacking a Mallard that has approached its brood during the exodus from the nest.

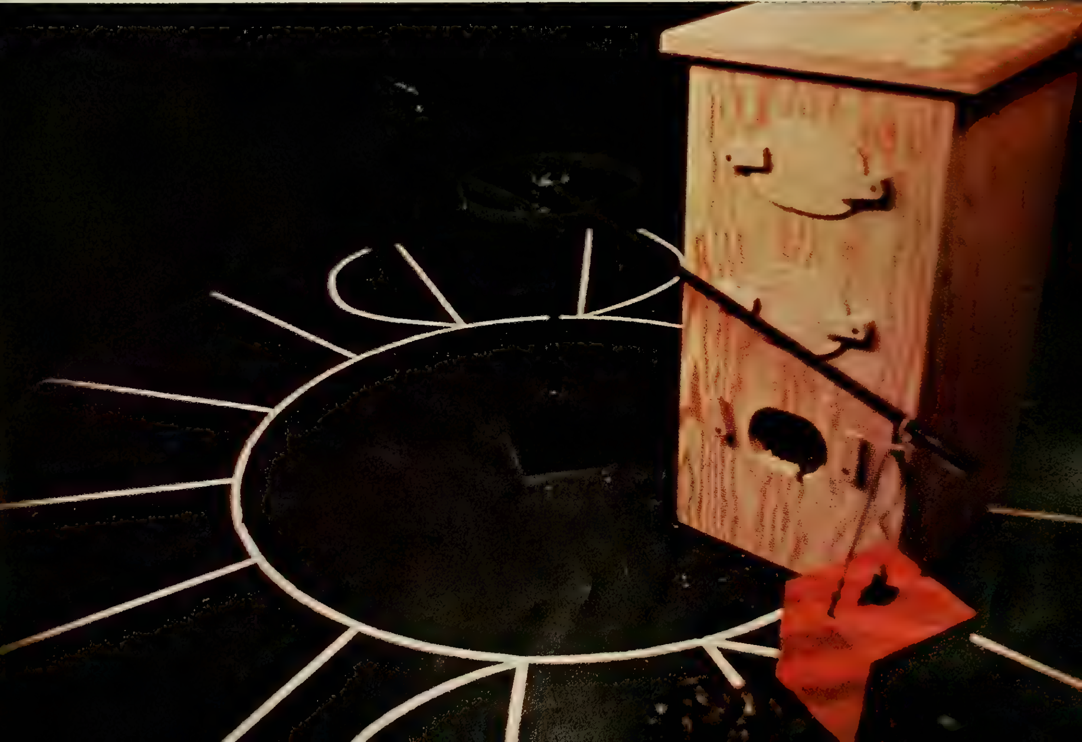
Most laboratory workers and theoreticians have proceeded on the assumption that parental and species recognition are largely, if not solely, a function of visual cues. In nature, however, it would seem that such recognitions are founded on auditory perception. Although our field studies do not definitely answer any questions about imprinting, they do suggest that the role of auditory stimulation has been underemphasized in laboratory practice and theory. Indeed, our subsequent laboratory research, using the parental exodus calls of various nidifugous species, suggests that certain key generalizations from imprinting research may apply *only* to the visual modality and may not be germane to parental and species recognition as such occur in nature.

As imprinting is a uniquely ethological idea, and ethologists are famed for their naturalistic emphasis, questioning the correctness of the imprinting formulation on the development of species recognition in birds living in nature may seem odd. In this regard, however, it must be recalled that the "original" formulation of imprinting (whether by D. Spalding, W. James, O. Heinroth, or K. Z. Lorenz) was not based on field observation. but on the behavior of young birds isolated from contact with their own parents and reared by surrogates from other species. Thus, although the relevance of imprinting to the formation of extra-specific filial and social ties in birds deprived of contact with adult members of their own species cannot be disputed, it does seem possible that the same mechanism may not be responsible for the formation of filial and social ties in birds reared by adults of their own species.

In summary, the results of our field work suggest that in nature auditory stimulation from the parent is a typical component of the stimulative complex which, at the very least, initiates parental recognition in ground-nesting as well as hole-nesting species of ducklings. Visual recognition factors would seem to come into prominence only after the initial establishment of the parent—young bond on the basis of auditory stimulation and interaction.



LABORATORY-HATCHED Mallard duckling climbs out of nest box, *above,* to approach the striped box that is emitting a recorded exodus call. In photograph below, all ducklings that were in nest box have gathered under their "parent."



# MAJESTIC WORKBOATS

# OF A PORTUGUESE LAGOON

### by NANCY FLOWERS

The Ria de Aveiro is a great salt-water lagoon cut off from the Atlantic Ocean by a long and narrow sandbank that stretches for thirty miles down the northwest coast of Portugal. The mouths of the Vouga and Agueda rivers have been dammed up by silt deposition, and their waters, mixed with those that sweep in through a channel dredged across the sandbank, have spread out to form a world of tidal swamps, reed islands, and floating and rooted water plants, bordered by low-lying croplands.

The boats that sail the canals and labyrinthine waterways of this vast lagoon are among the most beautiful in the world. They are called *moliceiros* (literally, slime boats), and they glide along the "thousand ways" of the ria to collect the *moliço*, or waterweeds, that grow in the brackish waters. The weed is then spread as fertilizer on the low, sandy land around the lagoon, and has, in the course of centuries, created a topsoil that makes the area agriculturally one of Portugal's best.

The ria shapes the life of the people who live along its margin. A peasant may farm his piece of land one day, go out to collect weed on the second, and fish on the third. This pattern has probably changed little since the land was first settled in prehistoric times, although its prosperity has depended on the state of the ria. We know that during the Middle Ages the ria was more open to the sea than it is today, and Aveiro, its principal town, was a large and important port. Gradually the outlets to the sea silted in, and at one time the region was almost depopulated. In the nineteenth century a channel was dredged, again making Aveiro a usable coastal port. It is now the home port of many cod-fishing schooners that sail for the Grand Banks in the spring and return in the fall with their cargoes of fish.

No one knows for how many centuries the people of the lagoon have been fertilizing their fields with the weeds of the swamps, nor is it known how long they have been building their graceful boats. Inevitably, their archaic shape and high, inward-curving prows remind one of early Egyptian and Phoenician ships. The people of the ria firmly believe that both they and their boats are descended from the Phoenicians who traded along these shores and are known to have founded colonies as far north as Lisbon, and possibly to Figueira da Foz.

One of the principal industries of the Phoenician colonies was the production of *garuna*, a kind of sauce made of salt fish, which was used for food seasoning throughout the Mediterranean area. In Cadiz and other sites in southern Spain and Portugal, archeologists have excavated the remains of salt pits used in the preparation of salted fish and *garuna*. Salt is still produced in the Aveiro region by evaporation from the tidal flats of the lagoon, but no Phoenician remains have been found there. A local historian has seen a reference to the ria in one poem by the fourth-century Roman poet Avienus, who speaks of an island on the western coast of Iberia formed of marine growths so unstable that the mere passage of a boat would shake it to its foundations. This is an excellent description of some of the reed islands in the ria, which sway like ripe wheat with every stirring of wind or water.

However, most Portuguese historians see the *moliceiro* and other boats of the north of Portugal as derived from the high-prowed, double-ended long ships of the Vikings, who raided and traded down the coasts of the Iberi-

*The wavy border painted on every prow may symbolize ripples on the lagoon.*

*igh forward curve of ornate prow helps*
*atman to maneuver through reeds.*

*Pine root, above, will form the boat ribs. Its curve is matched to template.*

an Peninsula during the ninth and tenth centuries. According to the Portuguese historian Jaime Cortesão, there are two influences on early Portuguese shipbuilding; first, that of the Vikings, which was strongly felt in the north of Portugal; second, that of the Moors from the Mediterranean who brought the lateen sail and a type of boat that evolved into the three-masted caravel that carried the Portuguese on their great voyages of maritime discovery in the fifteenth century.

Whatever its derivation, the *moliceiro* of Aveiro has become a boat perfectly adapted to its special task. It is usually about fifty feet long, of shallow draft and very low freeboard. The low sides allow floating weed to be raked directly into the boat. When a full load has been taken in, additional boards may be fitted into the gunwales to raise the freeboard so that the boat will not be flooded. The crew usually consists of two men, one of whom steers and attends to the trimming of the sails, while the other handles the rakes. Two wooden rakes, each about twenty feet long and with sixty-four teeth, are fixed to the boat's sides, and as she sails slowly along, the teeth catch the floating weeds. For the most part, the water is only about three to six feet deep, although it may reach some twenty or thirty feet in the channels. The men also use hand rakes to free weeds from the muddy bottom.

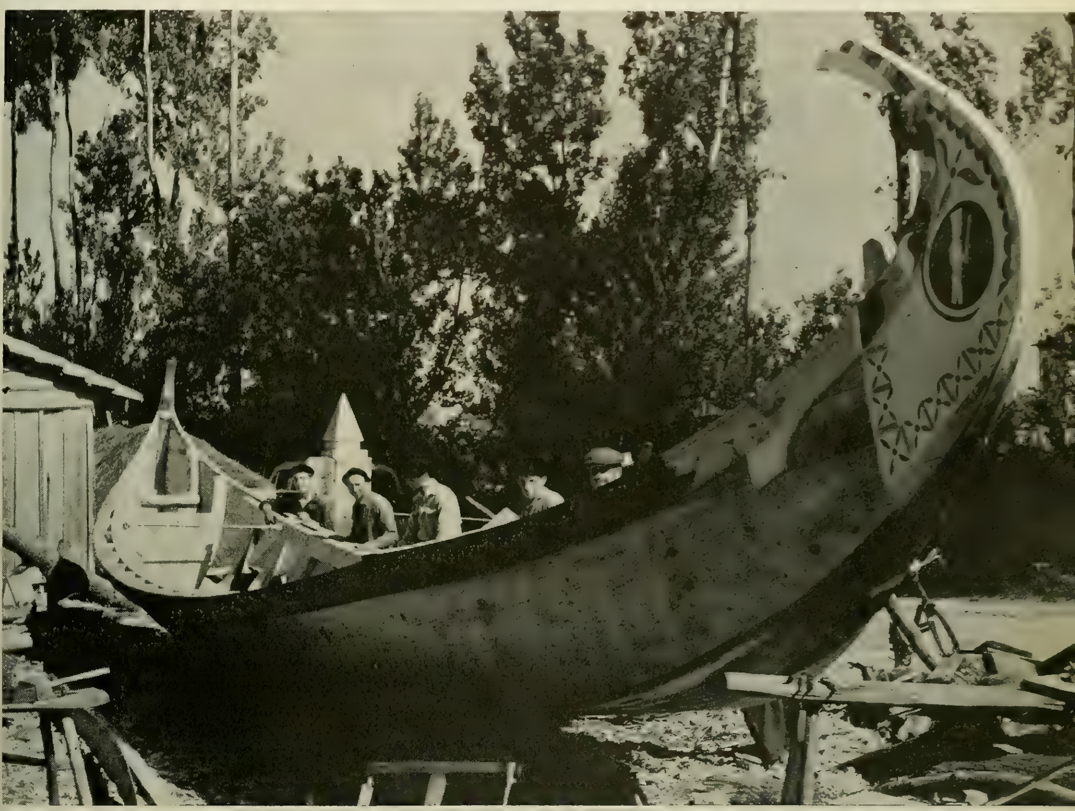
The weed collectors also often work chest-deep in water, tearing reeds from the muddy shores of the islands. The high forward curve of the *moliceiro's* prow makes it easier to beach the boat in shallow water and to pole it through reeds and floating vegetation. Probably the same reasons determined the similar bow shape of the ancient Egyptian ships that sailed the Nile over 3,000 years ago.

The *moliceiros* carry a tall, single mast with a large lugsail. When beating into the wind a leeboard is lowered. When the wind fails and the lagoon lies in mirror-like calm, the boats are poled or men pull them from along the shore by towropes. In this way, too, they make their way into Aveiro by the canal that passes through the center of the town. The high, curved

*Men at right follow a trade that has long been a tradition in their families.*

*Hinges, left, allow endposts to be lowered for passage under canal bridge.*

*Moliceiro, below, is ready for launching. It will sell for approximately $270.*

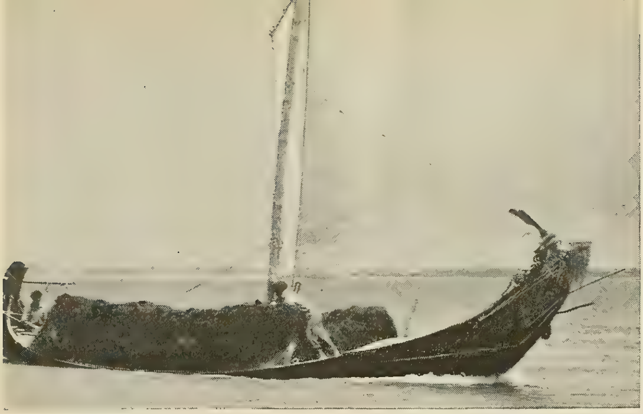


endposts of the prows are hinged so they can be lowered when they pass under the bridges that cross the canal.

The building of *moliceiros* is today virtually a hereditary craft, as there are families of the ria that have produced boatbuilders from as far back as their family tradition runs, and often three generations may be seen working on the same boat. At present the principal boatbuilding village is Pardilhó near the northern end of the ria. A man and a boy can build a *moliceiro* in six weeks, and it will cost the buyer the equivalent of about $270.

The ribs of the boat are not steamed and curved to required shapes as are those of most boats; they are sawed directly from a pine root that has the proper curve, and that is matched to a template. This is also the way the great Viking long ships found in ship graves in Scandinavia were built. As A. W. Brøgger notes in *The Viking Ships*, "For each rib a piece of timber was needed corresponding by natural growth to the transverse section of the ship."

The builder of the boat is also the decorator who paints the elaborate panels on prow and stern. Joaquim Roato, who has been building *moliceiros* for sixty years, is one of the most famous boat painters of Pardilhó, and he has several times won the yearly prize offered by the mayor of Aveiro for the handsomest boat.



*A moliceiro catches the wind in its large lugsail. When breeze dies down, boat is poled or is towed from shore.*

*Boatmen carry off the day's load of moliço, or weeds, collected from the banks and brackish water of the ria.*

*From ornate oxcart, below, moliço is spread as fertilizer to create rich topsoil for the farmland around the lagoon.*

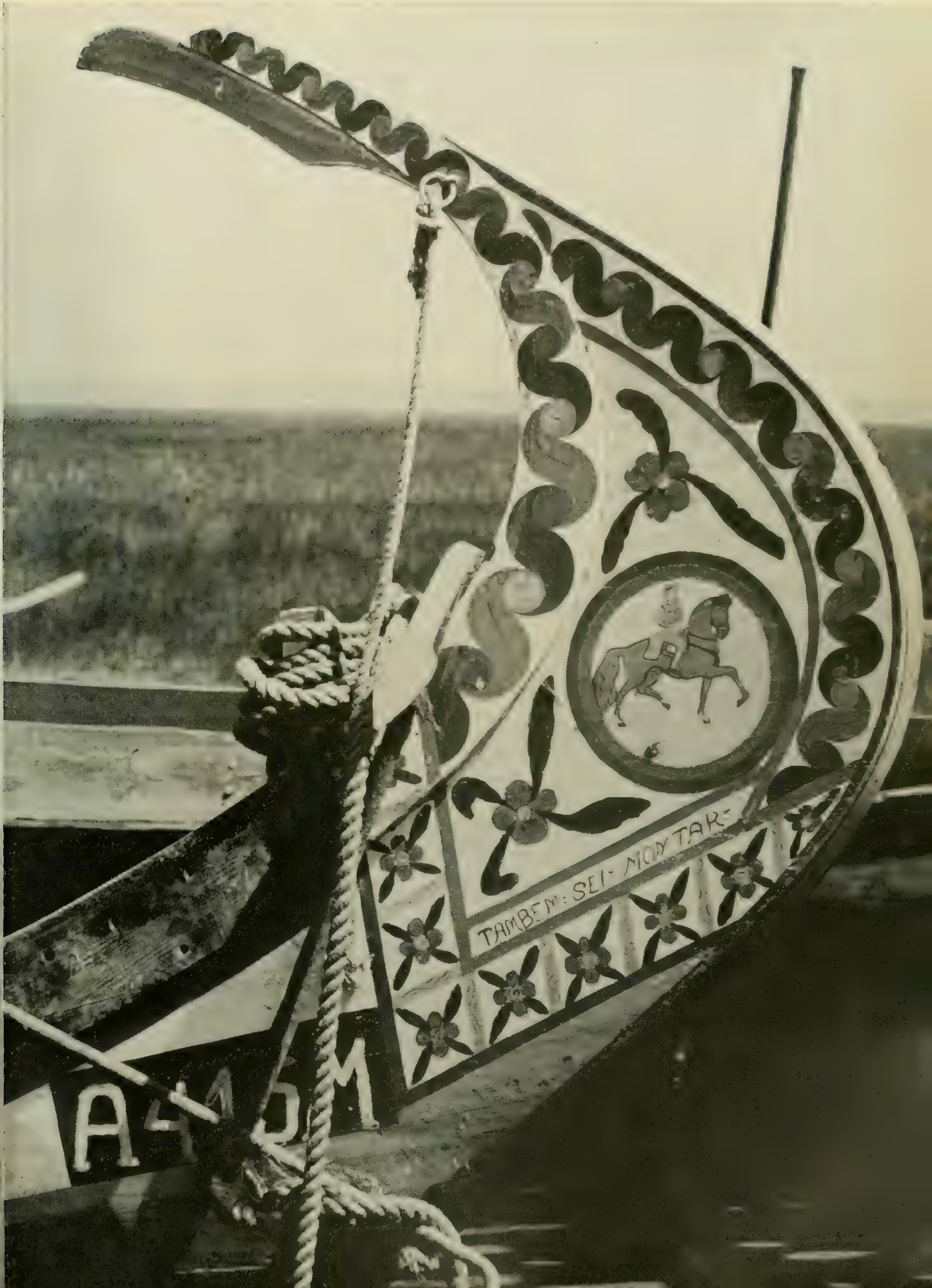
The general pattern of decoration is traditional, and it always includes a wavy border that may represent ripples on the lagoon. As if to symbolize the fertilizing power of the weeds when they are spread on the land, stylized flower and leaf patterns are usually part of the design. Each decorator uses these motifs as it strikes his fancy, and no two boats are ever painted exactly alike. As Joaquim Roato expresses it, "I paint as the wind turns me." The vivid, decorative border surrounds a central vignette, beneath which is written a "caption," or motto, often a piece of witty comment or earthy humor.

The variety of both the scenes and the mottoes is endless, but it is curious how often a man riding on a horse is shown. Is it possible that this also derives from a Phoenician tradition? We are told that the Phoenicians called their smaller boats "horses." However, the association of the idea of "boat" with that of "horse" is an ancient and obvious one, since a boat carries a man on water as a horse carries him on land. A ship shown in a rock carving that dates to around 1000 B.C., found at Vitlycke in Sweden, has a high, curved prow that terminates in what may be a horse's head (NATURAL HISTORY, November, 1964).

The village where the boats are built lies at some distance from the shore. Thus, when a new boat is finished it is placed on a two-wheeled sledge drawn by several pairs of oxen. The boat is adorned with little flags and bunches of wildflowers. Then it is slowly pulled through streets of the village while people stand at their doors to admire or to criticize. At the water's edge the boat is launched with due ceremony and turned over to its new owner.

In the boats that sail the waters of the Aveiro lagoon we can see the late flowering of a long and high tradition that began when man first cut down a tree to build himself a boat. In the hammer blows of a Portuguese boatbuilder on a crooked pine root we seem to hear the echoes of those that built the great vessels of Phoenicia from the cedars of Lebanon and the graceful Viking long ships from the oaks of the Scandinavian forests.

*The inscription beneath the emblem reads aptly, "I also know how to ride."*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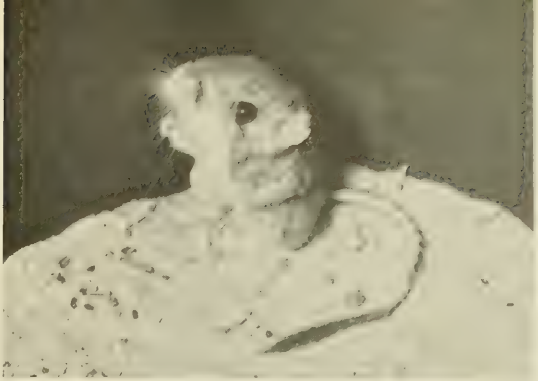


KANGAROO RAT measures from 9 to 10½ inches in length, not including the hairy tip of tail, which it cleans, at the left, in its characteristic manner.

ANIMAL is nocturnal and so is hard to photograph in the wild. One seen at left is a caged specimen that was live-trapped by author in Sonoran desert.

# Ears of Dipodomys

## Adaptations allow kangaroo rat to meet stresses of desert life

By DOUGLAS B. WEBSTER

SEVERAL years ago I found a small animal skull that had two bulbous swellings grossly distorting its posterior part. It was a typical skull of a kangaroo rat, and the swellings were this animal's fantastically enlarged auditory bullae—the skeletal coverings of the chambers of the middle ear. My subsequent investigations of the kangaroo rat's ear apparatus has already called upon several areas of biology—gross anatomy, microscopic anatomy, ecology, neurophysiology, pharmacology, and histochemistry—and it has not yet ended.

Before I could investigate intelligently the nature of these improbably large auditory bullae, it was necessary for me to learn a great deal about the animal as a total biological unit. For instance, the kangaroo rat is neither a marsupial, as are kangaroos, nor is it a real rat. It is a rodent belonging to the family Heteromyidae, which means "differing mice," and which also includes pocket mice, spiny mice, and kangaroo mice. It is called a "rat" only because it is larger than the other Heteromyidae. Its genus, *Dipodomys*, literally means "two-footed mice" and refers to its kangaroo-like stance and strongly bipedal locomotion, both of which are due to the great length and strength of the animal's hind legs.

Kangaroo rats live in semiarid to arid regions of the western United States and northern Mexico. They are nocturnal, spending the daylight hours in their cool underground burrows, and venturing out at night to forage for dry seeds. Since these are not always plentiful, the kangaroo rat probably benefits from its hoarding behavior and its large cheek pouches. The latter are not part of the mouth, as they are in most rodents, but are external pouches peculiar to kangaroo rats and closely related forms. They are large indentations, or inpocketings of skin, covered (that is, lined) with fur. They open on either side of the mouth and extend back into the neck region; therefore, they can hold a great many seeds. When an individual kangaroo rat has taken the edge off its hunger, it crams the cheek pouches full of seeds, using the front paws like a squirrel, and then hops back on its hind legs to its burrow. There, depending on the species, it stores the seeds either inside the burrow or in small, nearby surface holes dug with the forepaws. In the latter case, one can watch the cheek pouches being emptied by rapid forward swipes of the paws against the sides of the face, an action that produces an equally rapid firing of seeds into the holes.

If the outstanding feature of the kangaroo rat skull is the size of its auditory bullae, the most noticeable aspect of the living animal is the tail. About half again as long as the animal's body, it ends in a beautiful brush, or tuft, of hair: white for the appropriately named bannertail kangaroo rat (*Dipodomys spectabilis*) and black for the Merriam's kangaroo rat (*D. merriami*)—the two species I used—and black or gray in most of the other twenty-one species.

During leaps, this long and agile tail acts as a stabilizer to keep the animal upright in mid-air. Animals whose tails have been lost or damaged through unknown causes (or as an accidental result of my live trapping) are often wildly off balance while leaping, and sometimes even turn complete somersaults in mid-air. The tail also may be used to assist in steering the animal during long jumps.

ONE unusual aspect of the kangaroo rat's biology has been studied in great detail by Knut and Bodil Schmidt-Nielsen. They first confirmed what earlier observers had reported—that kangaroo rats can maintain themselves in a healthy state for extended periods of time on a completely dry diet, which is not as impossible as it may sound. All animals manufacture a certain amount of water as a necessary chemical by-product of carbohydrate and lipid (fat) metabolism. The kangaroo rat's diet, consisting as it does of seeds with a high percentage of carbohydrates, inevitably yields water as a metabolic by-product.

Thus, it is not in manufacturing, but in conserving water that the kangaroo rat is indeed unusual. All animals lose water through such functions as urination, defecation, and respiration, and most animals must replace this loss by drinking and/or eating foods with a high water content. The kangaroo rat, however, loses so little water that what is lost can be replaced entirely by metabolic water.

This stringent water economy, or water balance, is made possible by several anatomical and physiological modifications. Most mammals, for instance, have three major types of skin glands: mammary and sweat glands, which have water-base secretions, and sebaceous glands, which have a fat-base secretion. Mammary glands, of course, are only active following birth of the young. In kangaroo rats this occurs during the wet season of the year, and the extra water lost in the mammary secretions is compensated for by eating the seasonal green vegetation—something a non-lactating kangaroo rat need not do. Sweat glands are entirely absent in kangaroo rats. They do have sebaceous glands, whose secretion is used for grooming the fur, but this is a fat-base secretion.

Respiratory water loss is probably minimized in the kangaroo rat by means of the long, labyrinthine nasal passages, which appear capable of resorbing most of the moisture before the air carrying it has left the passages. Again, little water is lost during defecation, for the walls of the intestine resorb most of the water from the feces. Of course, some water is lost in the urine; but even here the kangaroo rat conserves. Its urine is greatly concentrated—about four times more so than human urine. In these diverse ways, the kangaroo rat balances the amount of water lost through various metabolic processes with the amount of water manufactured metabolically, and therefore can and normally does maintain itself on a diet containing no free water whatsoever.

All this information I found in various scientific papers. However, there were only vague generalities and speculative theories about what had originally captured my interest—the remarkable size of the auditory bullae. The answers, it seemed, were to be found in the laboratory rather than the library. I went back to the skull. A few measurements showed that the total volume of the cavities within the kangaroo rat's two

**Kangaroo-like, bipedal locomotion gives animal its common name. Notice stance, *above*, and long, strong hind legs, *below*. During leaps, the agile tail is used as a stabilizer, allowing animal to remain upright in mid-air.**

paper-thin auditory bullae is considerably greater than the volume of its cranial cavity; in other words, the two middle ears are larger than the entire brain of the animal.

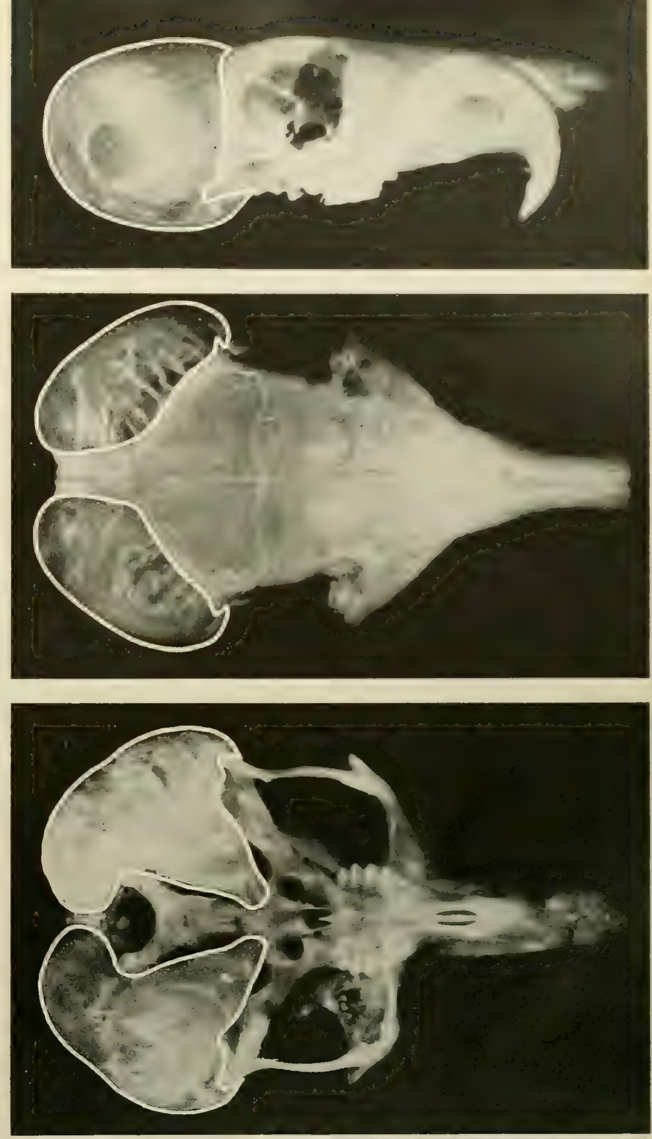
As seen at the top of page 30, the typical mammalian middle ear cavity is the air space between the eardrum (tympanic membrane) and the inner ear. Bridging this air space at its narrowest point is a chain of three small bones—the malleus, the incus, and the stapes—delicately suspended and elaborately articulated. The malleus is attached along its entire arm, or manubrium, to the tympanic membrane. The anterior process of the malleus is attached by the anterior ligament to the wall of the bulla, and two fine ligaments—the superior and the lateral—aid this suspension. The large head of the malleus articulates with the incus. The incus, in turn, is attached to the wall of the bulla by a posterior ligament; the long process of the incus has a 90° bend near its end, which causes it to articulate medially with the head of the stapes. Finally, the footplate of the stapes is held in the oval window of the cochlea by a fine annular ligament. Two very small muscles, the tensor tympani and the stapedius, run from the wall of the middle ear to the malleus and stapes respectively. Contraction of these muscles tightens the ossicular chain and reduces its ability to vibrate, thus acting as a safety device against damaging vibrations.

Sound waves pushing in on the tympanic membrane cause this apparatus to rock around an axis of rotation that runs through the anterior ligament of the malleus and the posterior ligament of the incus. Therefore, when the tympanic membrane is pushed inward, the manubrium of the malleus, the long process of the incus, and the entire stapes are rotated inward, and those parts of the heads of the malleus and incus that are dorsal to the axis of rotation move outward. As the tympanic membrane moves outward again, these motions are reversed.

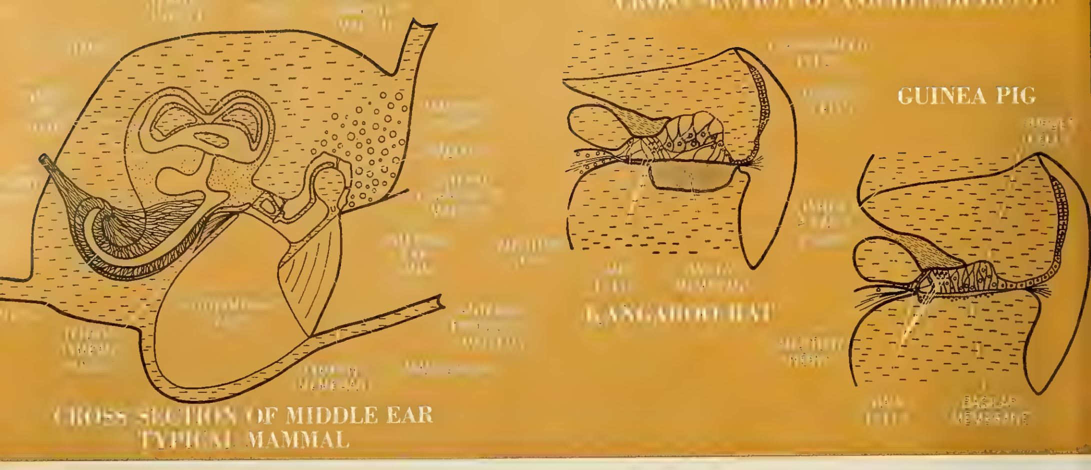
This tympano-ossicular system has a double function: to transmit to the inner ear the relatively weak air vibrations that strike the tympanic membrane, and at the same time to amplify them into vibrations of sufficient strength to move the inner ear fluids. It is not surprising, therefore, that the three bones should be suspended in an air cavity; any other suspension medium would impede their vibrations to such an extent that they could function neither as a transmitting nor as an amplifying mechanism.

Because sound energy must pass from vibrations in the air (before they strike the tympanic membrane) to vibrations in a fluid (after they reach the inner ear), a transformer mechanism is necessary. Recall that when your head is under water, you cannot hear sounds emanating from above the water. That is because most of the sound energy is reflected from the water surface instead of being absorbed by it. The middle ear transformer mechanism must, therefore, collect and amplify weak aerial vibrations so they can act effectively on inner ear fluids.

This tympano-ossicular transformer unit involves simultaneously a lever



Notably large middle ear cavities are seen, from top down, in lateral, dorsal, and ventral view. Outlines show the extent of these bullae, total volume of which is considerably larger than that of the "rat's" entire brain.



system and a piston system. The dynamics of the lever system depend upon the relative lengths of the manubrium of the malleus and the long process of the incus. To understand this, consider how a common nutcracker works. You apply a relatively weak force at the end of the handle (far from the axis of rotation), and the force on the nut (which is nearer the axis of rotation) has increased enough to break the shell. Similarly, the weak force on the manubrium of the malleus (handle) is increased at the end of the long process of the incus (nut) because they have different lengths and therefore are at different distances from the axis of rotation.

The dynamics of the piston system depend on the relative surface areas of the tympanic membrane and stapedial footplate. When the force (sound pressure) on the large area of the tympanic membrane is resolved onto the small area of the stapedial footplate, the force *per unit area* is increased as a function of the ratio of the two areas. The same principle is used in sailboats on which the large sail collects and concentrates the force of the wind, thus pushing the smaller hull through the water.

The theoretical total increase in force in the middle ear, then, is the product of amplification by lever and by piston mechanisms, and is called the transformer ratio. In man, the transformer ratio is 18.3:1, which means that, if there were no resistance to the movements of man's tympano-ossicular system, the force at the tympanic membrane would be increased 18.3 times per unit area when it reached the footplate of the stapes.

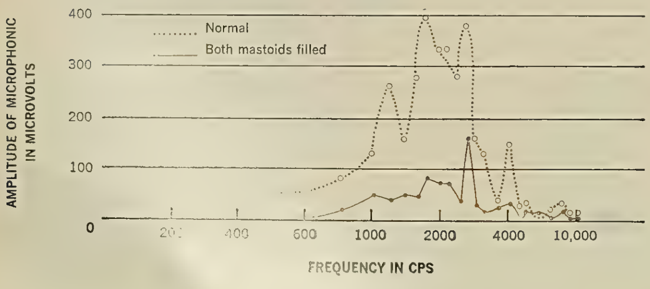
The actual increase in force is never as great as the transformer ratio would indicate, however, because this machine, like any machine, is not 100 per cent efficient. That is to say, some of the force that theoretically could be transformed into fluid vibrations is actually dissipated in overcoming the inertia of the system and in the friction caused by movements within the system (ossicles, ligaments, etc.). Therefore, to analyze the efficiency of the middle ear of any animal, one must consider both the transformer ratio and the resistance to movement of the tympanic membrane and the ossicles.

A careful anatomical study of the kangaroo rat's middle ear revealed several interesting characteristics. The enlargement of the cavity occurs mostly in the dorsal, or mastoid, portion (*photograph at top right*). In most mammals this is a small area of porous bone, but in the kangaroo rat it is a greatly enlarged air space that comprises 82 per cent of the entire middle ear volume. A thin lamina of bone divides it into a larger, anterior mastoid sinus and a smaller, posterior mastoid sinus, each of which independently communicates with the entotympanic cavity, or middle ear proper, where the tympanic membrane and ossicles are located. The cochlea forms a bulge in the entotympanic cavity's dorsomedial wall.

In kangaroo rats, the superior and lateral ligaments of the malleus are lacking, thus allowing the ossicles to rotate more freely. Also, the manubrium of the malleus is exceptionally long, and the tympanic membrane, to which it is attached, is unusually large. The stapes, especially in its footplate, is particularly small (*photographs at right*). All these variations from the "normal" mammalian situation add up to a middle ear of unusually large volume, with a tympano-ossicular system suspended with extreme delicacy, and a transformer ratio of 97.2:1—one and a half times larger than in any other mammal described in the literature.

From this morphological analysis of the middle ear, it appeared that the modified tympano-ossicular system provides the kangaroo rat with excel-

RESPONSES TO SOUND IN KANGAROO RAT

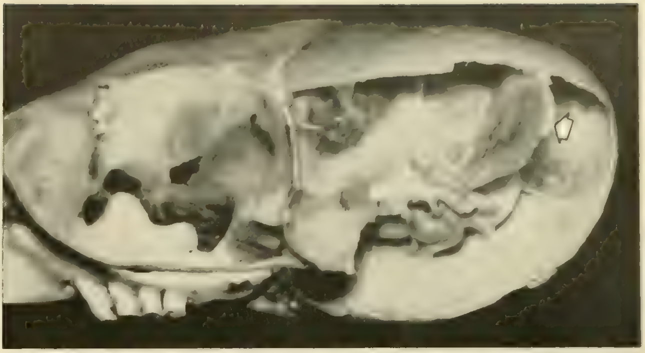


lent sound transmission to the inner ear. However, there was still no indication of the function of the amazingly large mastoid sinuses. Other scientists had suggested that these act as resonating chambers, in a manner roughly analogous to organ pipes. Since there was no evidence either for or against this hypothesis, I designed an experiment to test it.

Recalling that damage to the long tail resulted in equilibrium deficits, I wondered if damage to the enlarged middle ear cavity would result in hearing deficits. I performed surgery to open the middle ear and, carefully avoiding the tympano-ossicular system, I inserted an inert material (in most cases, plasticine) into the large mastoid sinuses. If, with this artificial loss in middle ear volume, the kangaroo rat's tympano-ossicular system was found also to have lost some ability to transmit vibrations, it would indicate that the large cavity improves this transmission ability.

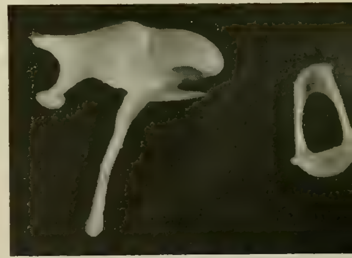
Transmission ability is most accurately measured by recording a bioelectric phenomenon, called the cochlear microphonic, which takes place in the cochlear portion of the inner ear during sound stimulation. This cochlear microphonic is an alternating electric current produced by the hair cells of the cochlea. It has the same frequency as the sound frequency that reaches the inner ear, and a current strength directly proportional to the intensity of that sound.

Now, for the sound to reach the inner ear and cause these bioelectric changes, the vibrations must normally be transmitted by the tympano-ossicular system. Therefore, if a sound (or series of sounds) of identical frequency and intensity is played to the animal both before and after some alteration of the middle ear, then the before-and-after cochlear microphonics must reflect any changes that have occurred in the ability of the middle ear apparatus to transmit vibrations to the inner ear.



LATERAL VIEW of skull with a portion of outer shell removed shows lamina (arrow) that divides posterior from anterior part of the middle ear cavity.

VENTRAL VIEW of inner ear shows the auditory ossicles and the cochlea.



DETAILS of ossicles show the malleus and incus at left, and stapes at right.

THIS procedure was carried out in the kangaroo rat; the alteration to the middle ear was the surgical reduction of volume as already described. The graph on the facing page shows the cochlear microphonic responses of the inner ear during stimulation by sounds that ranged from 100 to 10,000 cycles per second, both before and after the volume of the middle ear was surgically reduced. Note on the graph that the microphonic responses before middle ear reduction are greatest between 1,000 and 3,000 cps and that, within this range, there are three peaks of particular sensitivity—at 1,400 cps, 1,800 cps, and 2,600 cps. The great reduction of the microphonic responses following reduction of the middle ear cavity indicates that the transmission ability of the tympano-ossicular system has been severely curtailed. However, note again that the *peaks* of hearing sensitivity, although diminished in size, occur at the same frequencies in both the large and the small middle ears. Inasmuch as the peaks remain constant even when middle ear volume changes, they certainly cannot be reflections of the resonant properties of the middle ear, as had been postulated by some observers, for if they were, they would occur at high frequencies when the middle ear was reduced in volume.

The peaks of hearing sensitivity, as stated above, all lie within the frequency range of 1,000 to 3,000 cps, indicating that the kangaroo rat has its greatest auditory sensitivity in a much lower frequency range than do most small mammals, whose greatest sensitivity is to frequencies above 3,000 cps. The physical nature of vibrations is such that the lower the frequency, the greater the movement of the tympanic membrane. Obviously, inward movement of the membrane causes compression of the air within the middle ear cavity; the smaller the volume of this air, the greater is its resistance to compression. To clarify this, consider that if a cavity of two cubic inches is reduced by one cubic inch, the air contained therein is compressed into half its original space. However, if a ten-cubic-inch cavity is similarly reduced by exactly one cubic inch, then the contained air is compressed to only nine-tenths of its original space, which is much easier to accomplish. Similarly, an unusually large middle ear cavity that offers less resistance to movements by the tympanic membrane would make the transmission of sound energy through the middle ear to the inner ear very much easier than it would be in a smaller middle ear cavity. And this would be especially true for sounds of low frequency, where greater tympanic membrane movement must occur.

Understanding of this, however, still does not explain the adaptive value of the mechanism. I moved the investigation into the field, where I hoped to discover sounds with frequencies in the extra-sensitive range from 1,000 to 3,000 cps, the detection of which would be vital to the survival of the kangaroo rat—sounds produced, for instance, by predators.

Two of the chief predators of small desert rodents are the owl and the rattlesnake. The owl (as reported in NATURAL HISTORY by R. S. Payne and W. H. Drury, Jr., in "Tyto alba: Marksman of the Darkness," June-July, 1958) can hunt successfully in total darkness. This it does, not by seeing in the dark, but by listening for a small rodent to pause in its normal movements. Then, by a sort of triangulation method, the owl determines the exact location of sound cessation, and flies directly to that spot.

A different but equally successful method of hunting in the dark has evolved in the rattlesnake. The anterior part of the snake's head contains an unusual sense organ, the pit organ, which is extremely sensitive to temperature change. This "anatomical thermostat" is activated by variations as small as three thousandths of a degree, and can detect the presence of the human hand at a distance of thirty centimeters. By means of this device, the snake can locate small, warm-blooded animals even in total darkness. The kangaroo rat, therefore, while foraging for food at night (and desert nights can be exceedingly dark) is at the same time being foraged for by at least two types of animals that do not need to see before striking. Obviously, the prey can use help.

In the summer of 1959 I went to the Arizona desert to study predation at first hand, with three specific objectives: (1) to learn if the normal kangaroo rat could avoid predatory attempts by the owl and/or the rattlesnake; (2) if so, to discover whether it could still do this after the volume of the middle ear cavity was reduced; and (3) to determine if during predation the owl and/or the rattlesnake produced any detectable sounds between 1,000 and 3,000 cps. In carrying out these investigations, I used the facilities of the Southwestern Research Station of The American Museum of Natural History, near Portal, Arizona, and the Arizona-Sonora Desert Museum near Tucson.

For the first set of experiments I used barn owls or screech owls in large outdoor cages, in which I placed kangaroo rats. A microphone and tape recorder collected data, which could be simultaneously monitored by earphones from the tape recorder. Some of the tests were also observed by a red light, which these nocturnal animals do not see but which renders them visible to a human observer.

As an owl swept down toward the kangaroo rat, a faint whirring could be heard if, and only if, the tape recorder was set at maximum amplification. Except for this, owl flight is noiseless. Later analysis of this whirring sound showed it contained all frequencies up through 1,200 cps. Just as the owl was about to seize its prey, the kangaroo rat escaped by a spectacular, nearly vertical leap of approximately one and a half feet, and a landing at a different point, usually about a foot from where it had begun. Then it hopped away with no noticeable haste. The owl did not attempt to chase it—the normal owl reaction when prey is missed on the first attempt. However, if the kangaroo rat used in the experiment was one with artificially reduced middle ear volume, the owl invariably caught it.

Similar experiments were carried out using a sidewinder rattlesnake. The rattlesnake was placed in a large, outdoor box with a sand-covered floor, and was observed to strike unsuccessfully at a kangaroo rat five times during a three-hour period. The kangaroo rat avoided the snake in much the same way as it had the owl, making no attempt at escape until the moment of the strike. In fact, leap and strike occurred almost simultaneously, so that the observer was unsure whether or not the snake had hit its target until its intended victim was seen hopping away. These attempted strikes were recorded, as were the owl's attempts, with the volume of the tape recorder turned to full capacity. Later analysis of the tapes, with a sound spectrograph, revealed that immediately before the rattlesnake struck it produced a brief burst of sound covering all frequencies up to 2,000 cps—perhaps a hiss, a rattle, or even scales rubbing against the substrate preparatory for the strike. When a kangaroo rat with reduced middle ear volume was placed in the box with the sidewinder, it was struck successfully on the first attempt and devoured by the snake, although in this case, as well, the strike was preceded by the same sound frequencies.

Correlating this series of observations with anatomical, physiological, and behavioral information about the kangaroo rat, I could at this point propose a consistent explanation of the adaptive value and functional significance of the kangaroo rat's enlarged middle ear cavities. The increased size of the middle ear air space decreases damping (the resistance to tympano-ossicular system movement), and thereby increases the sensitivity of the tympano-ossicular system, especially in the low-frequency range.

Such a condition is a logical outcome of the evolutionary process of natural selection. Two chief predators of the kangaroo rat have specialized sense organs that allow them to hunt in total darkness. Therefore, any specializations that would aid the kangaroo rat in avoiding snakes or owls in the dark obviously would have an important adaptive value.

Thus I was able to clear up some of the initial problems about the structure, physiology, and evolutionary significance of the enlarged middle ears of the kangaroo rat. But, as always, new questions arose. One of the most challenging concerns the structure of the cochlea, where the change from physical vibrations to nerve impulses occurs. This portion of the ear is extremely uniform in all mammals, and the cellular structure of its sensory portion, the organ of Corti, also is essentially the same. Therefore, I was considerably surprised to discover that the kangaroo rat's organ of Corti contains cellular and acellular structures quite unlike those that have been described in other mammals. A cursory examination of the drawings of the organs of Corti in the kangaroo rat and guinea pigs (*page 30*) shows the larger size of the kangaroo rat's basilar membrane, on which the organ of Corti rests, and the unique, flask-shaped cells found in the latter structure. Even the more basal border cells differ considerably in shape and cy-

ADAPTATIONS permit kangaroo rat to live for extended periods on dry diet.

tology from those in the guinea pig. As yet I do not know what the functional or phylogenetic significance of these structures may be; I am currently determining what enzymes are present in the various portions of the organ of Corti and am comparing guinea pigs and kangaroo rats for similarities and/or differences. Such a comparative approach may eventually tell us more about the way the ear functions at the molecular level in the kangaroo rat, the guinea pig, and perhaps in mammals in general.

Another result of these studies has been the realization that the kangaroo rat's enlarged middle ear is not unique, as I had first thought. In fact, since I saw my first kangaroo rat skull, I have learned of several other groups of rodents and a group of insectivores that have, independently of one another, evolved greatly hypertrophied cavities of the middle ear. These groups include the gerbils, jerboas, and springhaas of northern Africa and the steppes of the Near East, the jirds of Mongolia, and the elephant shrews of South Africa. Although different portions of the middle ear may be hypertrophied in different forms, the general structural characteristics are remarkably alike. Furthermore, these groups are all behaviorally similar. They all live in arid or semiarid regions. All have enlarged hind limbs and employ a kangaroo-type of locomotion. All are nocturnal. In other words, animal groups independently evolved in widely separated parts of the world, have developed amazingly similar structural and behavioral patterns to meet similar environmental problems. The stresses of desert life are great, and several forms, including the kangaroo rat, have become highly successful in contending with those particular stresses.

Herein lies a rich area for fruitful study of parallel evolution, a phenomenon that has never been fully analyzed and understood. Having seen the gross similarities in these different forms, for instance, one wonders how much similarity there may be in their finer structure, physiology, and their behavior. Do they have a similarly modified cellular structure in the organ of Corti? These questions and others await further investigation.

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PHOTOGRAPHIC MAGNITUDES
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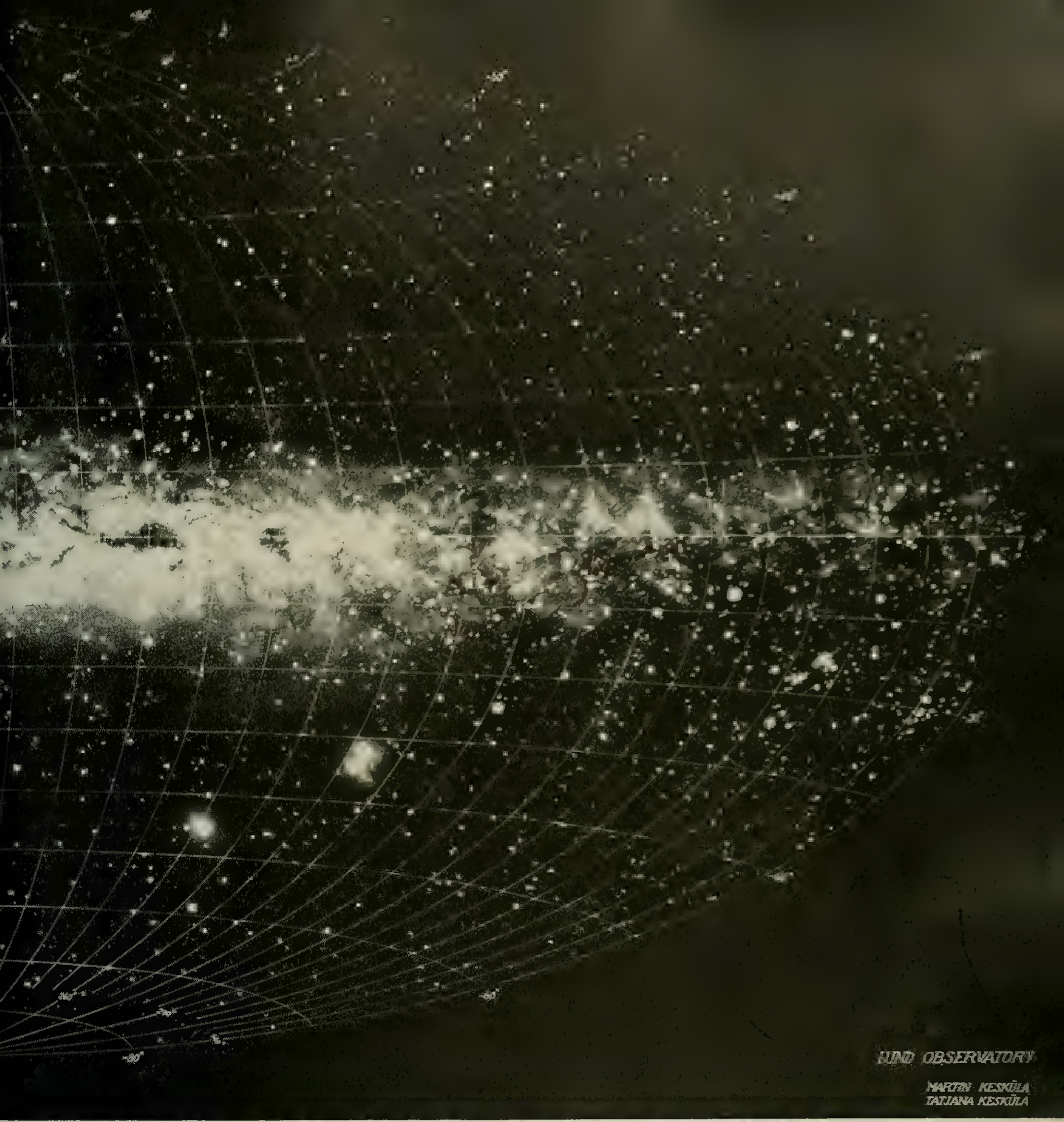
# SKY REPORTER

## Our Galaxy, the Milky Way, is a flat, thin island of stars

By Thomas D. Nicholson

Should you have the chance to sweep the February skies with binoculars or a small telescope, you will not fail to notice how much more numerous the stars seem to be in certain regions than in others. A particularly star-rich band extends from the constellation Cassiopeia, in the northwest, up through Auriga, east of Taurus, and down to the southeast horizon to the right of Canis Major. This is the region of the Milky Way, identified on the star map on page 37. If you happen to live some distance from the interference of lights from a city, you should be able to see the Milky Way with your unaided eye on very clear, dark nights. This remarkable belt of brightness, which continues full circle around the sky beneath the horizon, was chosen



**Entire Milky Way** is seen in drawing, based on photographs, that plots a 360-degree view of earth's sky on galactic grid.

as the Sixth Wonder in the Planetarium story of the Seven Wonders of the Universe.

Known since antiquity, the Milky Way received its name from the "milky" appearance of its bright clouds against the darkness of the sky. The discovery that the clouds of the Milky Way were composed of stars is attributed to Galileo, first to observe the heavens with a telescope. In 1610, Galileo wrote, in *Sidereus Nuncius*, "I have observed the nature and the material of the Milky Way. With the aid of the telescope, this has been scrutinized so directly and with such ocular certainty that all the disputes which have vexed philosophers through so many ages have been resolved, and we are at last freed from wordy debates about it. The galaxy is, in fact, nothing but a congeries of innumerable stars grouped together in clusters. Upon whatever part of it the telescope is directed, a vast crowd of stars is immediately presented to view."

This discovery by Galileo can be duplicated easily by anyone who possesses even the most inexpensive type of optical equipment. The stars that produce the Milky Way's brightness are too far distant to be observed as points of light by the unaided eye, as the nearest stars can be observed. Yet, the stars are grouped in such vast numbers along that belt of the sky that their combined brightness is seen as the hazy patches of light that make up the Galaxy.

The concentration of stars along the Milky Way led astronomers and philosophers of the 18th century to speculate that the stars of our sky were arranged in a lens-shaped cloud, finite in extent, with its central plane extending out along the Milky Way, which was surrounded by starless space. During the 19th and early 20th centuries several attempts were made to determine the size and structure of this lens-shaped island of stars. The results indicated that the Milky Way did indeed represent a somewhat flattened disk of stars surrounding the earth in space, but they gave no indication of the true size of the system.

In trying to probe the extent and structure of the star system represented by the Milky Way, 19th-century astronomers faced the same problem that hinders study today—the presence of vast clouds of interstellar gas and dust. In some areas along the system, these clouds are glowing brightly; in others they are dark and obscuring. At any rate, this cosmic murk prevents our seeing deeply into the star mass. This partially explains why early attempts to explore it seemed to indicate that the earth was located approximately in its center. We can only see the Milky Way for certain distances; we cannot see how much farther it may extend in one direction than in others.

But fortunately, astronomers found ways of measuring what they could not see. Harlow Shapley, as we saw in the "Sky Reporter," January, 1965, made the brilliant assumption that the globular clusters are the beacons of the Milky Way. Then he located their center and defined the extent of the globular clusters by determining their distance and direction from earth. The center of the system lay in the direction of Sagittarius, where the star clouds of the Milky Way are particularly rich and bright. There, according to Shapley, is the invisible center of the Milky Way itself, revealed by the structure of the globular cluster system, even though it is hidden far beyond vast, obscuring clouds of gas, dust, and stars. Shapley went on to describe the size and structure of the Milky Way, as he understood it. Except for revisions of distances and the modification of some details, our concept of it today is essentially the same as Shapley described in 1918.

The stars of our sky do indeed represent an island within the universe, limited in its extent, surrounded by starless space. We call this island of stars our Galaxy. The Galaxy is flat and thin, sometimes described as disk-shaped, or, as earlier astronomers referred to it, lens-shaped, like two saucers placed face to face. The flat part of this Galaxy extends into space around us along the plane where we see the Milky Way. Over the years, our Galaxy has come to be referred to as the Milky Way because, as noted above, the only form in which we are able to see it from earth with our naked eye is as an undefined, milky expanse of stars, gas, and dust. In a sense, then, the name Milky Way can be used ambiguously. It may mean the hazy band of light we see in the sky, or it may mean the system of stars that band represents—the Galaxy. The context in which the name is used will generally make clear what is meant.

The Milky Way—referring now to our Galaxy—extends about 100,000 light-years across and is about 10,000 light-years thick at the center, where a dense hub of stars is found. The clouds of stars, gas, and dust that surround this central hub fan out along the plane of the Milky Way in arms that spiral around the center. The hub and central disk of the Galaxy are in turn surrounded by an almost spherical halo of stars and globular clusters. There are at least 100 billion stars in the system, and there may be twice that number. One of these stars is our sun, buried deep within the central plane along one of the spiral arms, about two-thirds of the way from the center. The entire Galaxy is like a giant, spiral-shaped wheel, turning most rapidly in the center, more slowly out along the arms.

Our knowledge of the size and structure of our Galaxy has been strengthened in recent years by two methods of exploring, both of which verified the early picture of the Galaxy as provided by Shapley. First, studies of the motion and distribution of certain classes of very bright stars have shown the location and motion of several arms of stars in that part of our Galaxy that is within about 10,000 light-years from the sun. Among those identified are the Orion arm, in which the sun is located, the Sagittarius arm, which is closer to the center of the Galaxy, and a third—the Perseus arm—that is more distant from the center.

A second modern technique for exploring the structure of the Milky Way has developed through radio astronomy. Invisible clouds of neutral hydrogen located among the star clouds of the Milky Way radiate energy of 21 cm. wavelength, part of the radio spectrum. These clouds share in the circular motion of the Galaxy; therefore, any part of their motion that is along the line of sight can be detected by a shift in the frequency of the 21 cm. energy they radiate. Careful analysis of the direction and velocity of the clouds detected along the Milky Way has shown that they are located in spirals around the center of the system, corresponding approximately with the arms of stars in the Galaxy. Thus, the size and structure of the spiral arms of stars along the central plane of the Milky Way are revealed by the hydrogen clouds, to the extent that the location of the hydrogen provides us with a guide to the location of the stars.

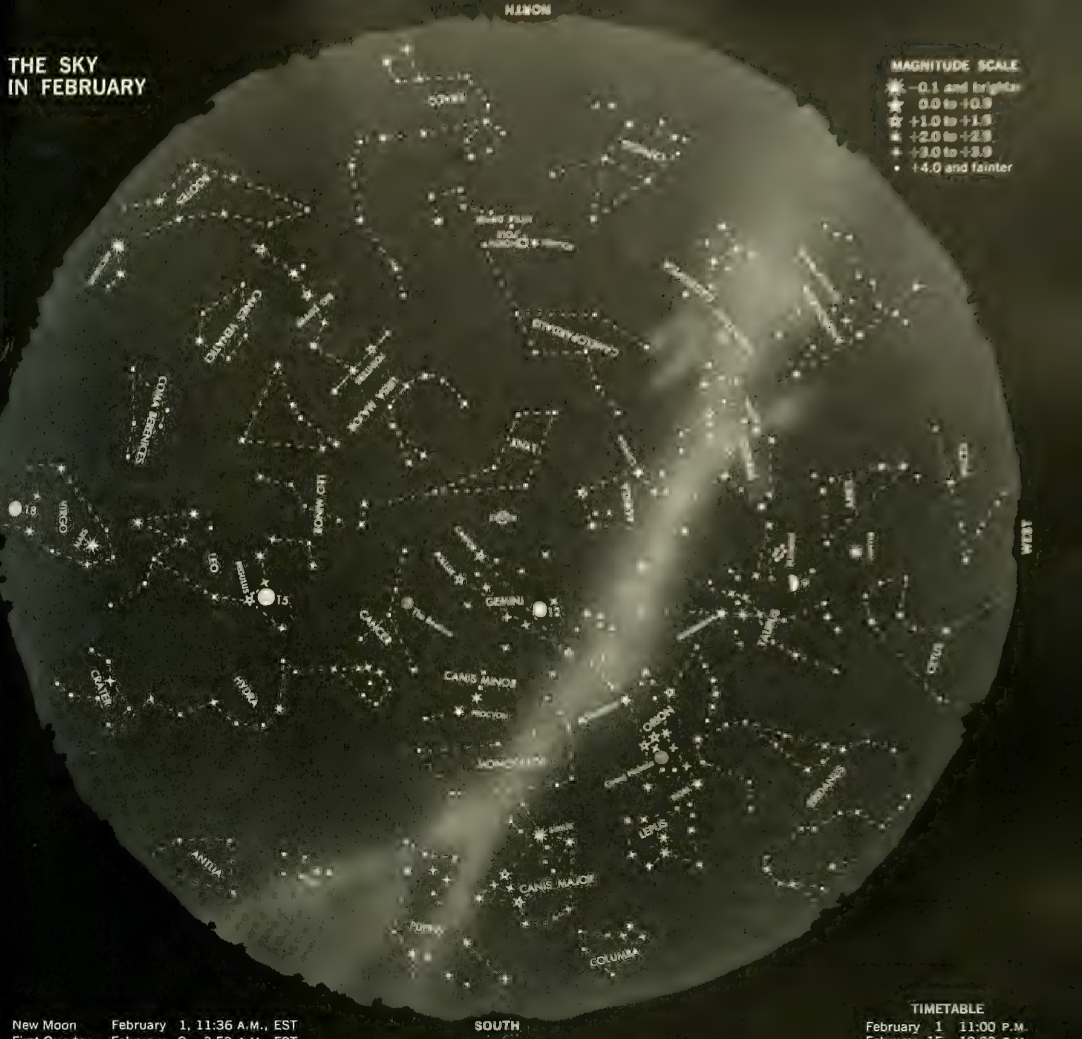
Thus far in our story of the Seven Wonders of the Universe we have seen that stars are not immortal and do not extend infinitely into space. We have explored the process by which stars are created and the events that may accompany their death. And this month we have seen what kind of a system the stars of our sky belong to. Next month, in the story of the Seventh Wonder, we shall discuss what lies beyond the starless space that surrounds our Galaxy.

Dr. Nicholson, the regular author of this column, is also Chairman of The American Museum-Hayden Planetarium.

### MARS APPROACHING OPPOSITION

On March 9, Mars will be opposite the sun in our sky. As opposition approaches throughout the months of January and February, the distance between earth and Mars rapidly diminishes, and the planet grows dramatically brighter in our sky. On January 1, Mars had a stellar magnitude of +0.5. By February 1, it brightens to −0.2, and it will be −0.9 by the end of February. This change of 1.4 magnitudes, which has been taking place since the beginning of the new year, represents an increase of about 3½ times in the brightness of the planet.

# THE SKY IN FEBRUARY


NORTH
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
BOOTES
CANES VENATICI
COMA BERENICES
URSA MAJOR
LYNX
LEO MINOR
VIRGO
18
LEO
Regulus
15
CRATER
HYDRA
CANCER
The Beehive
GEMINI
12
CANIS MINOR
PROCYON
MONOCEROS
ORION
Great Nebula
LEPUS
SIRIUS
CANIS MAJOR
PUPPIS
COLUMBA
ANTLIA
TAURUS
CETUS
ERIDANUS
WEST
SOUTH

| | |
|---|---|
| New Moon | February 1, 11:36 A.M., EST |
| First Quarter | February 9, 3:53 A.M., EST |
| Full Moon | February 15, 7:27 P.M., EST |
| Last Quarter | February 23, 12:39 A.M., EST |

TIMETABLE

| | |
|---|---|
| February 1 | 11:00 P.M. |
| February 15 | 10:00 P.M. |
| February 28 | 9:00 P.M. |

(Local Mean Time)

February 3: Saturn is in conjunction with the early crescent moon at about 5:00 A.M., EST. Saturn is now too close to the sun and too faint to be seen easily.

February 8: Look for Jupiter and the nearby first quarter moon in tonight's sky. After sundown, they are in the south, and the moon is slightly west (to the right) of the brilliant Jupiter. If you watch closely, however, you will see the moon move eastward (to the left) slowly to pass under Jupiter along about 10:00 P.M., EST. The moon will move, with respect to Jupiter, a distance equal to its own diameter each hour. After the conjunction at 10:00 P.M., the moon will be to the east of the planet.

February 17: If you have not seen Mars yet this winter, be sure to look in tonight's sky. Just look for the moon (two days past full), and Mars will be the brilliant, reddish, starlike object a little to the right (west) of the moon. At 5:00 P.M., EST, the moon and Mars are in conjunction, even though they have not yet risen to a position over the United States whereby they can be observed. In parts of south and east Asia, however, the moon can be observed to occult the planet.

February 23: Mercury is at superior conjunction (in line with the sun and earth, but on the far side of the sun), and passes into the evening sky.

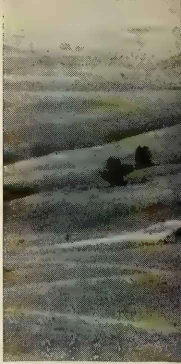
February 26: Saturn is in conjunction with the sun and becomes a morning star.

Jupiter becomes visible in the south soon after sunset in early February. On the 7th, its elongation from the sun is 90 degrees easterly, so that it sets just about six hours after sunset. Toward month's end, it appears in the southwest as darkness comes on and sets well before midnight. Jupiter is easily distinguished by its brightness (magnitude −2.0 in early February, fading to −1.8 at the end of the month). It is located among the stars of Taurus, west of the Pleiades (see map above).

Mars is in Virgo, but becomes so much brighter this month than it has been all winter that stargazers may be surprised when they see it and may wonder where it came from. The planet rises shortly after sunset each evening and remains visible throughout the night until it disappears into the growing twilight of the morning sky (see box on opposite page).

# Flowers, Insects, and Evolution

## Specialization developed from mutual adaptations



By Herman F. Becker

Any endeavor to unravel the evolutionary history of our fascinating flower–insect relationships reveals divergent interpretations among scientists. For such an undertaking a comprehensive knowledge of the natural sciences is required, especially of geology, botany, entomology, and, above all, of paleobotany, paleoentomology, and evolution. Many people realize the existence of interdependence between some plants and insects, but few are aware of the aeons of time involved during which this process reached its present state of development. Evolution has no definite end result and never a deliberate, predestined direction. In the case in point, it is expressed by a high degree of specialization and an intricate relationship that developed into such widely divergent biological entities as the flowering plants and the insects.

**Fossil** of *Rosa hilliae* Lesquereux resembles many rose leaves of today.

First, of course, we must consider the interdependency between plants and insects that exists in nature today; then we must apply the dictum, "The present is a key to the past." The geological record presents a chronicle of 400 million years of fossil life that can be traced through each subsequent younger formation. The evolution of each living plant and insect has been a continuous chain of events, which, if broken, would have resulted in extinction. In turn, a complex and harmonious interdependency—or mutualism—exists between many plant and insect species. If that interdependency should be severely disrupted, mutual annihilation could result.

Early organization of flower structures appears to have been a slow, gradual process of adaptation and specialization without functional stimulus by insects. When the first insect-like animals appeared during Devonian time, the evolution of highly specialized reproductive structures among such plant groups as the seed ferns, the treelike club mosses (*Lepidodendron, Sigillaria*), and the giant horsetails or scouring rushes (*Calamites*) was already well on its way. Early "insects," according to fossil evidence, were doubtless primitive, wingless, and unspecialized. Their food requirements were not restricted, but may have comprised a varied diet of decaying debris.

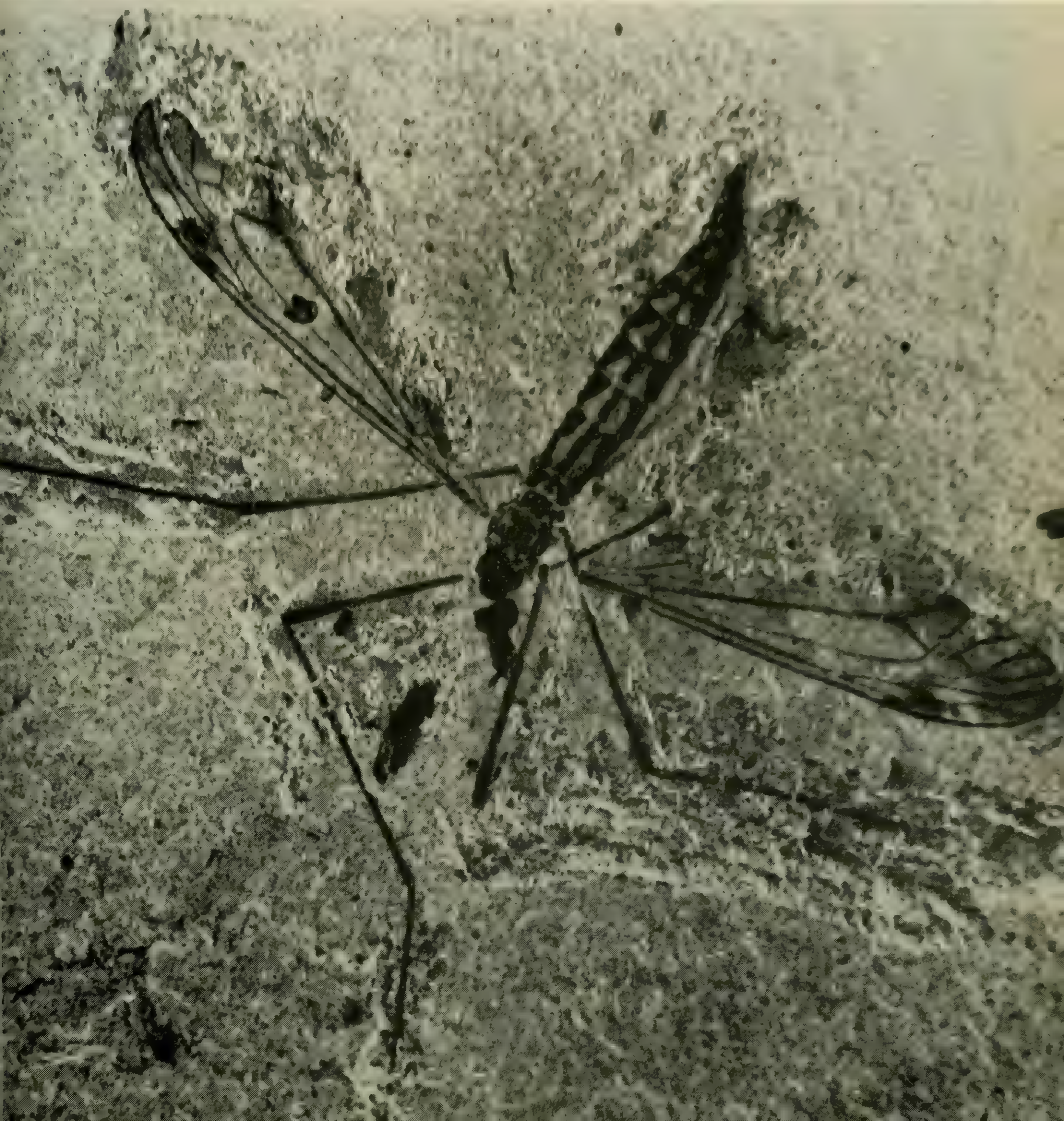
The reasons for the sudden rise and expansion of the angiosperms—the higher plants, which have seeds enclosed in an ovary—are still shrouded in mystery, but a phylogenetic plasticity coupled with favorable ecological opportunities surely played a major role in their rise. Their explosive diversification and dispersal in the late Cretaceous and early Tertiary nearly parallels an equally momentous rise and diversification, or speciation, among the insects. An intimate interdependence between these two groups, therefore, must be considered a relatively recent geological phenomenon —one initiated about 70 million years ago. Most earlier relationships probably were essentially haphazard, and at first contributed little to the eventual physiognomy and requirements of either plant or insect.

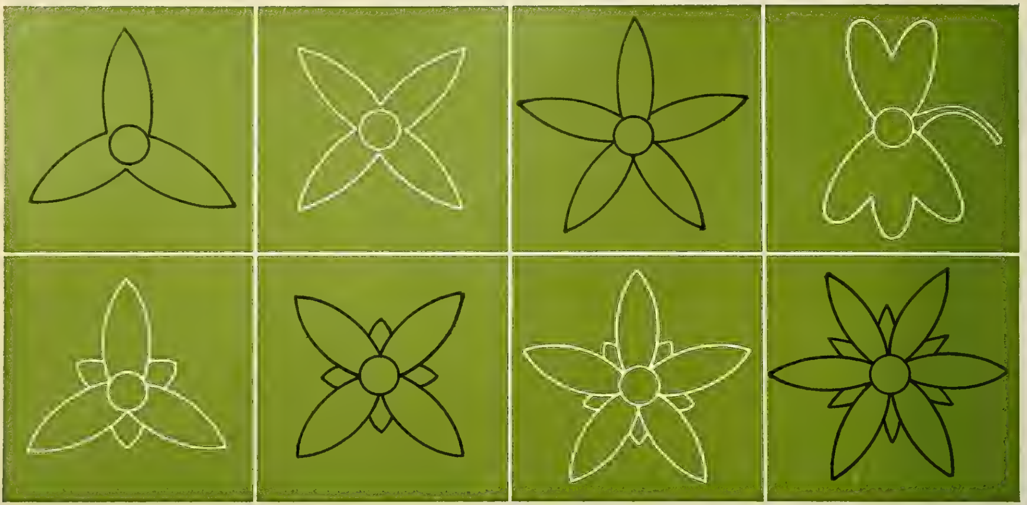
Nothing in nature is constant but change. In a nutshell, organic evolution, expressed in terms of phylogenies, is "descent with modification" as a function of perpetual genetic variation, mutation, and natural selection. Those traits that do not contribute to species survival are gradually discarded. In rare cases, according to fossil evidence, species remain in a state of what might be called "evolutionary suspension," or *status quo*. That is, they have changed relatively little either because their environment has not changed, or because they are adapted to a wide range of environments. Cases in point are such examples as the "living fossils" of the Dawn Redwood (*Metasequoia*), the Katsura tree (*Cercidiphyllum*), *Ginkgo*, and, to some extent, the roses. Among the insects, the dragonflies, roaches, and silverfish fit into the living fossil category.

Essentially, then, over a long period of time, each gradual and minute change in both flower and insect morphology was triggered by subtle genetic and environmental changes. In some cases, our interpretation of an

UPPER Ruby River valley in Montana is site at which the author collected some 12,000 plant and insect fossils.

CRANEFLY (Tipulidae) was buried in the Ruby sediment during Oligocene Epoch more than 36 million years ago.





**Many insects distinguish flowers by petal and sepal forms, as in pattern combinations above. Upper row shows petal types from simple to complex; lower sequence includes the sepals. Recognition is the key in pollinating relationships.**

early phylogeny is only as valid as the fossils on which it is based, and additional fossil material that comes to light frequently causes us to reconsider and modify previous conclusions. This procedure permits a flexibility to amend previously established plant–insect relationships according to new evidence.

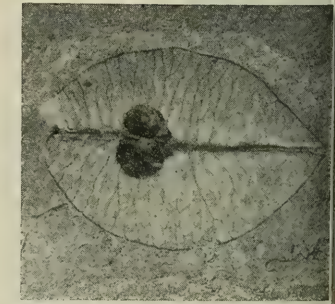
Some of the early insects of the Carboniferous and Permian periods were doubtless carnivorous or omnivorous, while herbivorous forms were destructive to plant life. It has been suggested—as a hypothetical beginning to plant—insect interdependencies—that there gradually appeared cells that secreted nectar. These surrounded the reproductive (flower-like) regions, and the feeding activities of insects began to be channeled toward such central lures. This, then, may have resulted in the preservation of vegetative structures and, concurrently, promoted the transfer of microspores and insured pollination. From such convergent developments arose a mutualism that was beneficial—in some cases a survival factor—for plants and insects alike.

It is sometimes assumed that flower types were determined by their exploiters, the pollinators. To the uninitiated, the examples are superficially plausible when we say that "bumblebee flowers," such as clover, arose in response to specific structures of the bumblebees; that "bird flowers," such as cardinal-flower or trumpet-vine, arose in response to parrots and hummingbirds; and that "bat flowers" —*Kigelia* (the tropical sausage tree) or certain cacti—developed in response to bats. Such reasoning assumes an independent "leading" development of the fauna with a resulting adaptation of flowers to their visitors. It can hardly be argued that the insects are the sole exploiters of flowers for food as long as the flowers equally "exploit" insects for pollination—an exchange that results in harmonious relationships to each other's advantage.

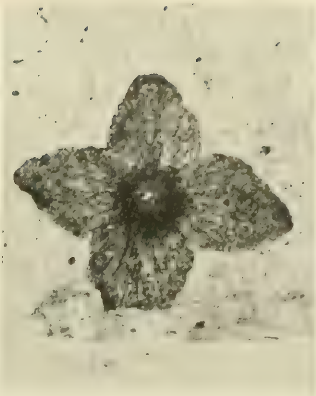
Many instances of insect behavior toward plants may be traced to a functional structure, color, or fragrance in plants, and one might be tempted to say that insects "behave" in a particular fashion *because* of these attributes. Whether the insects directed or caused the evolution of flowers to conform to their own entomological specializations is certainly not decipherable from the geological record. But if they did so, it would follow that flowers must always have lagged behind insects in their optimum adaptation. It is more realistic to assume that reciprocal adaptation among primitive and advanced flowers and insects was achieved contemporaneously or in a limited, seesaw fashion.

Secretion of nectar, for instance, is physiologically linked with flower maturity, the opening of stamens, and the discharge of pollen. Nectar glands, or nectaries, of the earliest flower types attracted primitive arthropods of the class Insecta. Floral parts provide a region where sugars, starch, albumen, fats, and vitamins accumulate to be incorporated into developing fruits and seeds. Nectar and pollen thus furnished, then as now, a concentrated and palatable food for the arthropod visitors who "learned" to utilize these sources for their daily needs.

Today, insects are divided into two great subclasses, the wingless Apterygota and the winged Pterygota. Wingless insects entered the geological stage during early Devonian time and have remained relatively unchanged and primitive to this day. They contain the



**Fruit of China-tree, now native in Asia only, was found in Ruby shales.**



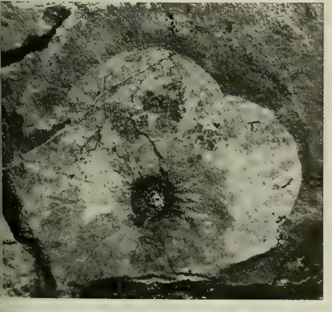
**Dogwood blossom**, *above*, is among the fossils representative of the Oligocene.

**Leaf** of an alder tree, *left*, suggests that its environment was once moist.

**Fine venation** of elm leaf compression, at right, shows excellent preservation.

present orders of Thysanura, with bristle tails or caudal filaments and chewing mouthparts (silverfish), and the Collembola, minute—or even microscopic — vegetarian springtails. Only one in a thousand of all insect species is wingless today. Pterygota appeared somewhat later, but the exact time of derivation from the wingless forms is problematical, and the morphological changes that resulted in wing development are still not clearly understood. The attainment of winged flight precedes that for reptiles and birds by nearly 100 million years. This mode of locomotion obviously unlocked new vistas and evolutionary potentialities for the whole group. Nearly 200 million years elapsed before the greatest number of insect species took to the air, which coincided with the early Tertiary ascendancy and diversification of the flowering plants.

Among the Pterygota, the Palaeoptera, or ancient-winged, had outstretched, non-flexible wings that could not be folded flat over their bodies. Dragonflies and mayflies are examples. They were mainly predaceous, and evolved into the largest insects that ever lived. Fossil dragonflies with a wingspread of 30 inches are not uncommon. Toward the end of the Carboniferous the Palaeoptera gave rise to the new-winged insects, the Neoptera, which could fold their wings. Today, 90 per cent of all existing orders of Pterygota, comprising 97 per cent of all species, belong to this group.



**Today**, ***Holmskioldia**, **above**,* **grows in Southeast Asia and Madagascar only.**

**Fruit** of today's Penny-Cress, left, is compared to fossil specimen, right.

For the first 100 million years following the origin of the winged insect, the air was shared with no other organism. They reigned supreme until the Jurassic and the advent of the birds, which soon turned the insects into a source of food. Neopterous insects of the Upper Carboniferous, related to our cockroaches and stoneflies, had an incomplete, or hemimetabolous, metamorphosis, in which each stage was larger than the previous until adult size was reached. Insects with a complete, or holometabolous, metamorphosis—that is, those that go through grub and pupal stages—appeared in Lower Permian times and comprised about 5 per cent of all insects. Today, 88 per cent of all insects are in this group; their larvae and caterpillars differ from adults in structure and in food and ecological requirements.

One of the keys to the successful evolution of pollinating relationships is the faculty of insects to distinguish diagnostic forms of basic flower types that consist of a definite number of sepals and petals (*drawing, page 40*). Such structures are termed "numeral" patterns and were first recognized in "flowers," or fructifications, in the cycad-like plants of the early Mesozoic. Gradually, through various evolutionary lines, they attained their present angiospermous complexity of ovary-enclosed seeds. Perhaps one evolutionary system of flower "type classes" may be equated with a complementary sensory evolution of pollinating insects. During the progress of natural selection, each previous sign of "recognition" on the part of the insects was augmented by a new, more adaptive, and more successful sign. Primitive, spirally arranged, beetle-pollinated magnolias of the Cretaceous, for example, gave rise to some modern species (*Magnolia denudata, M. coco*) with a radial symmetry and a more efficient pollination by Hymenoptera.

**Bumblebee** may have been vital as a pollinator of Oligocene flora.

**Mirror image** of ichneumon wasp, *right*, was found between shale pages.

THE following botanical terms in their evolutionary sequence telescope these trends:

*Amorphic*, or "structureless," extinct flower types usually possessed dense whorls of leaves or bracts, often without definite form, and growing beneath the floral reproductive structures. Some of the Triassic ancestral cycads with amorphic "flowers" (*Wielandiella*) attracted certain primitive beetles and roaches, and possibly some wingless insects that learned to associate the pollen and secretory food supply with the density of whorls of bracts or basal leaves of the flowers.

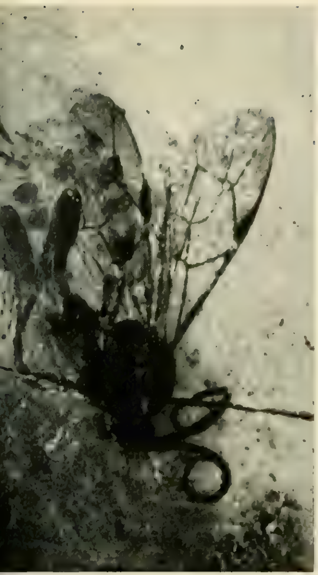
*Haplomorphic*, or "simple," flowers, in their often "spiral" arrangements of variously colored petals and sepals (the perianth), trace their ancestry to the middle and late Mesozoic Era. Magnolias, the tulip tree, and waterlilies belong in this group, which is considered to be one of the most primitive among the angiosperms.

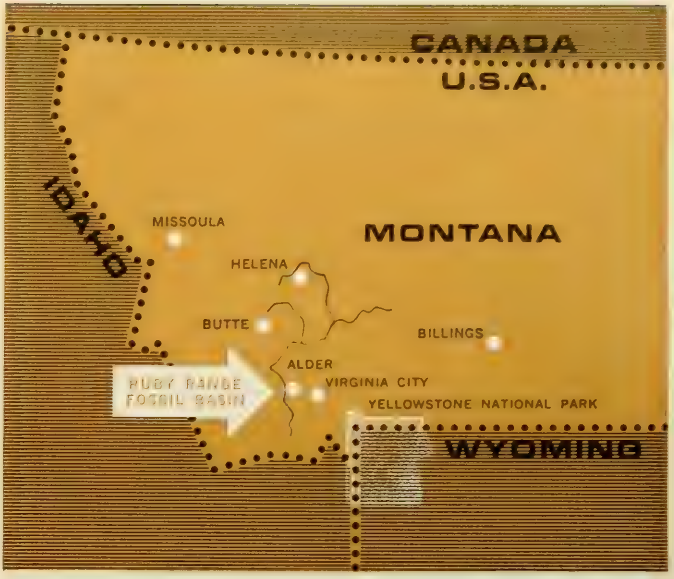
*Actinomorphic*, or "regular," flowers have emerging "radial" and two-dimensional symmetries. Roses and peonies, which have all floral parts and nectaries on one level, are examples. Here are associated composite, radial forms of from three- to six-perianth segments that probably are perceived by the insect as a unit. Together with color and fragrance, these flower types represent a food attractant for certain flies or bees and a few other well-adapted pollinators, including beetles, that need no specific ability to gather the abundant pollen offered. No flowers of the truly radially symmetrical type have been reported from the Cretaceous Period.

*Pleomorphic* flower types (the root word means "more than one"), with a four- or five-part recognition pattern, were found in Cretaceous beds, but they became abundant only in Tertiary floras. Some lily-like compressions of the Tertiary suggest bee pollination, as in modern, colorful monocotyledonous flowers with a

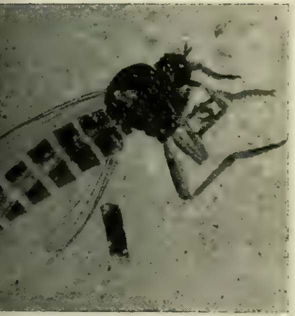
**Insect** with a striped abdomen has been identified as a hymenopteron.

**Tropical grasshopper** from Ruby site is now extinct in United States.



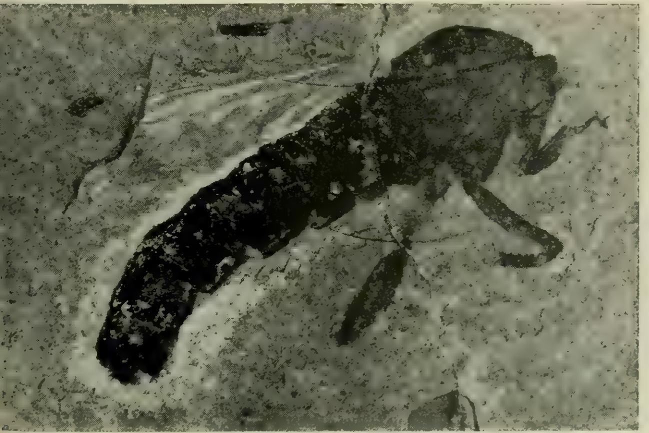


**Oligocene** fossil area is 70 miles northwest of Yellowstone National Park.



**Antennae**, wing veins, and limbs are well preserved in stiletto fly, *above.*

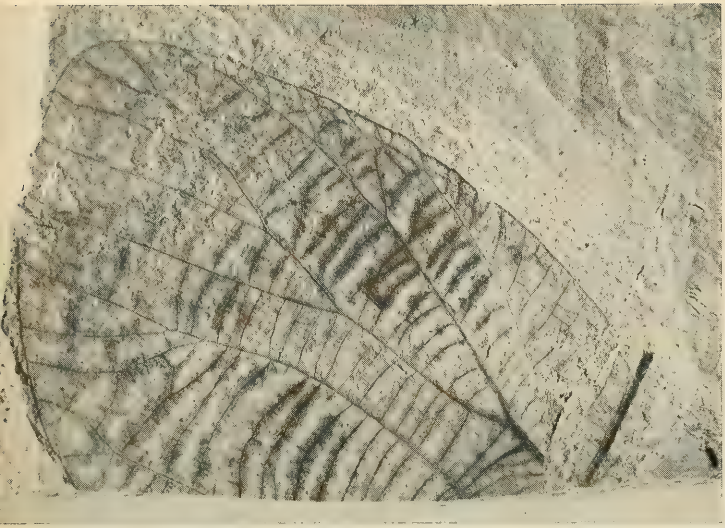
**Specimen**, possibly a robberfly, is magnified 3½ times its actual size.



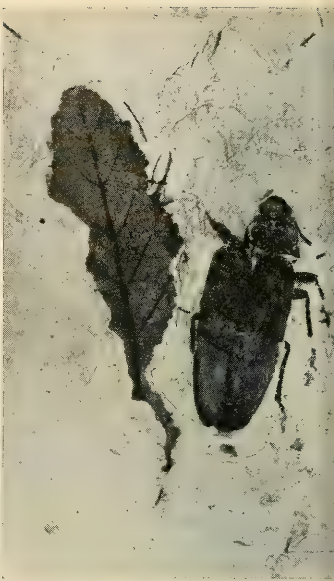
three- or six-part perianth. Flowers of the mustard and dogwood families were first recognized in the Oligocene Ruby shale deposits of southwestern Montana, of some 35 million years ago. Bees (including bumblebees) and flies (including flower flies) were abundant by then, and may often have chosen specific flowers on which to feed.

*Stereomorphic*, or three-dimensional, often tubular, flowers with a symmetrical three-, five-, or six-parted perianth, are a late Tertiary derivative from pleomorphic ancestry. They include gentians, bellflowers, columbines, primroses, phlox, and daffodils. Their corollas protrude considerably above the deep-set and often concealed nectaries. Butterflies and hawk moths, some of which have refined adaptations of mouthparts (a long, curled tongue, for instance), or certain bees (which, with long tongues or very small bodies, are able to force entry into the tubes) feed on and pollinate stereomorphic flowers.

*Zygomorphic*, or bilaterally symmetrical, floral development represents the highest and most intricate evolution of morphological structures in response to, or contemporaneous with, a very limited number of pollinators whose sensory organization is attuned to a highly specialized perianth. These perianths offer complicated recognition patterns together with nectar and fragrance that must be grasped in their entirety, as was experimentally shown, no matter how ornamented their symmetry may be. Zygomorphism crosses the boundaries of many families (orchids, milkweeds, legumes) and demonstrates what may be the ultimate in floral specialization. Orchids and their pollinators pose the greatest morphogenic and taxonomic problems to an investigator. They do not always con-



**WING** is well preserved due to volcanic ash content in the Oligocene sediment.



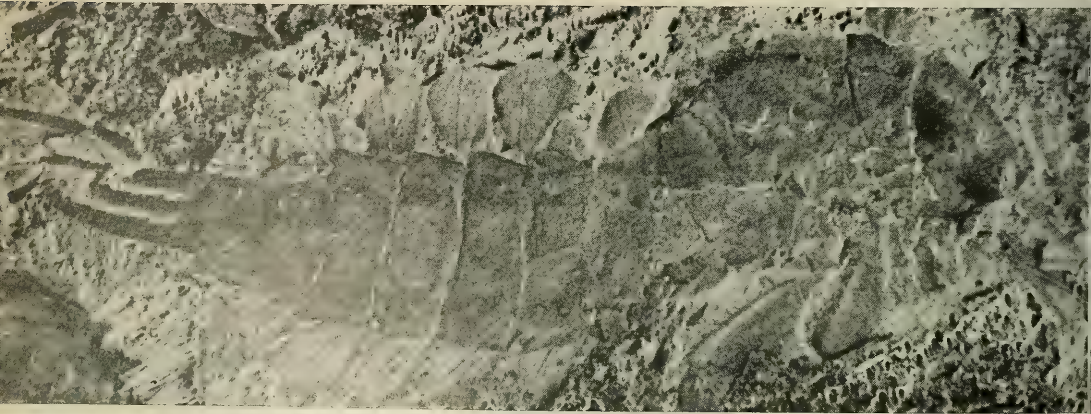
**BEETLE FOSSIL** rests on same segment of paper shale as alder leaf, *right.*

form to botanical criteria that are considered valid for other families. For instance, they possess unique pollen structures, the pollinia, which adhere as units to the visiting insect (often flies and moths), and are thus assured of delivery to a receptive stigma of the same species. This is made easier because the highly adapted pollinators regularly visit the same kind of flower.

THROUGHOUT evolutionary time each flower type, from the amorphic to the zygomorphic, has corresponded to a concurrent level of sensory adjustment in those pollinating insects that had the greatest reaction to a particular plant. Such adjustments continue to evolve, if imperceptibly, without the sacrifice of previously existing, advantageous flower–insect relationships. The story of the present adaptation of insects to their flower hosts, and the intricate endowment of flowers to lure, attract, trap, deceive, and feed pollinators to their own ends is a source of wonder. Even birds and bats entered the competition when specialized structures and functions, serving the pollination of the host, arose with equally efficient features for food requirements of their vertebrate visitors. This resulted in an advantageous, mutual dependence.

After these more or less theoretical considerations, let us now look at some specific aspects based on relatively recent discoveries of plant and insect compressions in our own western backyard. During the summer of 1947, I found the first Tertiary plant compressions in the upper Ruby River basin of southwestern Montana. I could not foresee, however, the significance of that find until I showed a shoe box

**MAYFLY NYMPH,** with visible leaflike gills, has been enlarged 9 times here.



full of fossil leaves and assorted insects to Dr. C. A. Arnold of the University of Michigan. He immediately recognized the scientific potential of the flora and encouraged me to expand the collection. That suggestion resulted in seven additional field trips during the next fifteen years, and an accumulation of about 12,000 specimens, including some 200 species of plants and a great number of insect remains.

Among paleoentomological regions, the Oligocene Florissant sites of central Colorado had been the most lucrative and best-known in the United States, and this fauna was exhaustively described seventy-five years ago by S. H. Scudder. The Ruby plant sites rank second only to those of Florissant in richness of insect species and may surpass them in detail of preservation.

The Ruby River valley is 70 miles from Yellowstone National Park in a basin of the Rocky Mountains formed by geological faulting. It is flanked by the Ruby and Gravelly ranges. During most of Tertiary time, the entire valley was occupied by a lake in which a sequence of sediments was deposited. A vegetation much denser and more varied than that of today supplied leaves and other plant debris that were carried into the lake by numerous streams and buried in the mud. A high mineral content of the water and a possible absence of decay organisms provided favorable conditions for the preservation of organic remains, including insects that had been washed or blown into the lake.

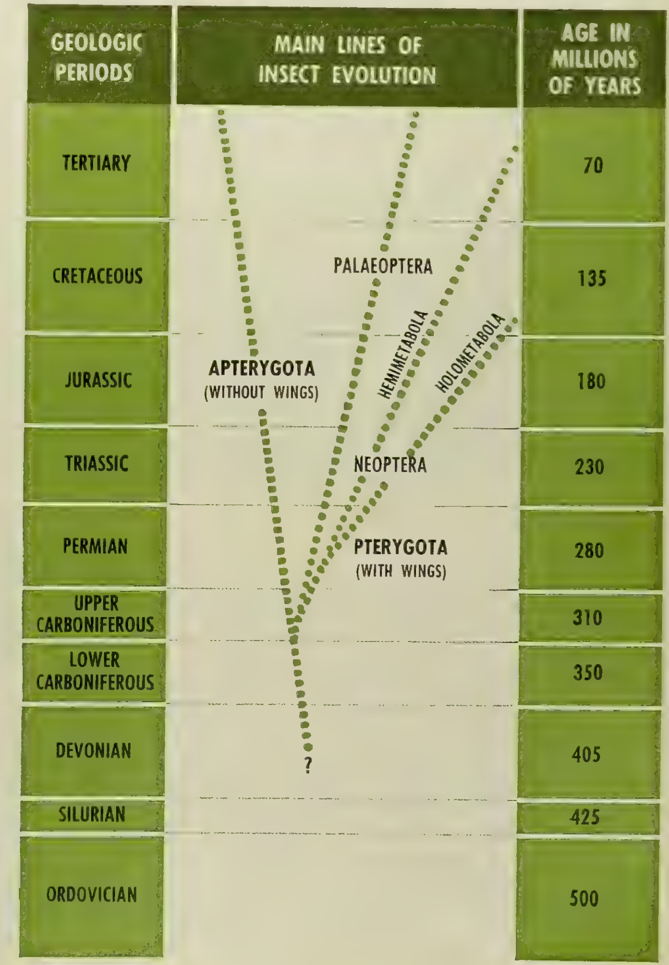
Fossil sites exposed along the walls of dry washes consist of laminated, light-colored shale that separates along some of its bedding planes. Where such rock is exposed to annual subzero temperatures and to baking during the summer, it splits into progressively thinner slabs. These are the "books" of shale with their "pages," or layers, so thin that the slightest breeze will waft them into the air. It is this "paper shale" that contains the fossil compressions of most plants and insects at the Ruby sites.

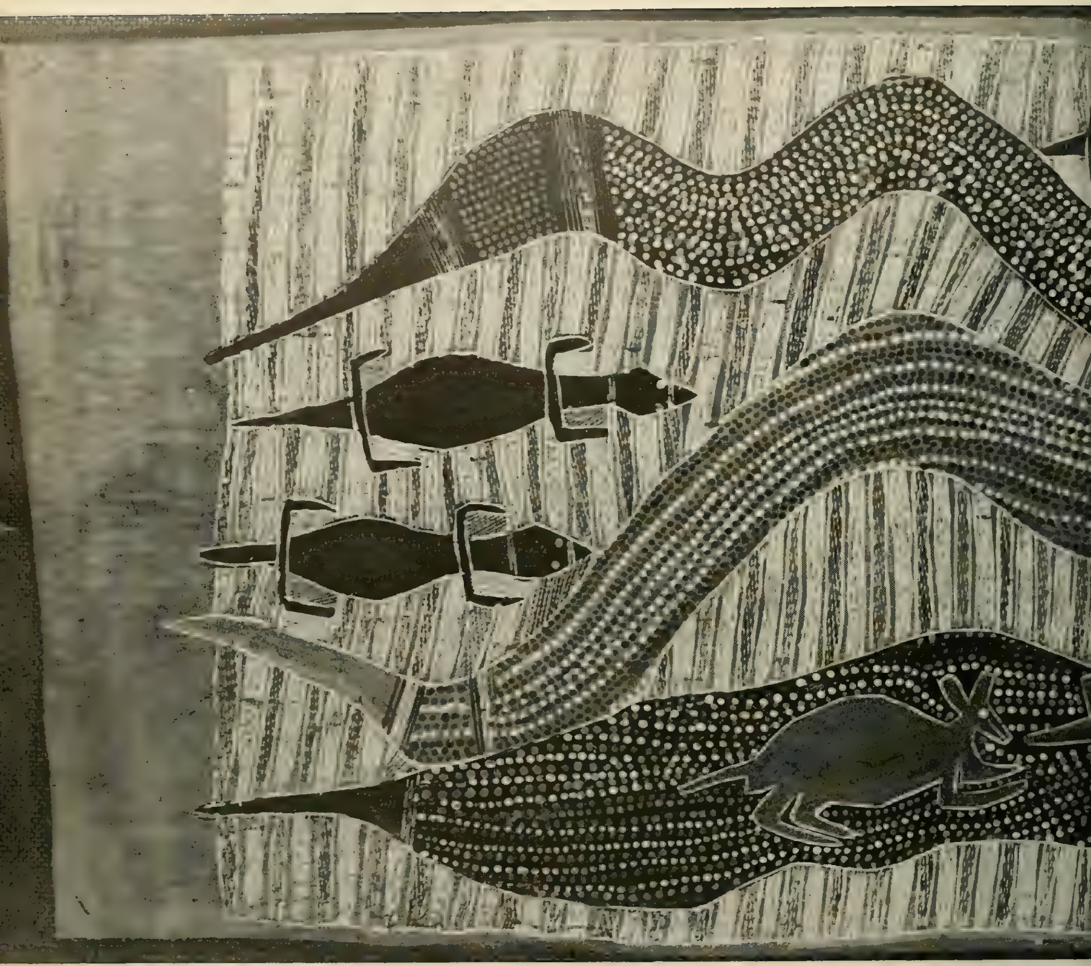
We rightfully assume that the large, varied Ruby River basin insect fauna was attuned to the equally varied angiospermous flora of trees, shrubs, and herbaceous plants, and that a dependent relationship existed between these two groups. This image is recreated from fossils nearly fifty times as old as mankind itself—from plants and insects that left nothing but films of carbon, which are sharp, clear replicas of their former selves.

The Ruby fossil plant assemblage provides an eloquent basis for local divisions of vertical life or climatic zones, each with its adapted entomological fauna. In most cases, diagnostic criteria for fossil insect identification are sufficient to place them in their proper orders, families, subfamilies, tribes, and even genera. Their taxonomic status is therefore accurate except on the species level. The entomological sample of the Ruby shales probably represents but a small fraction of the genera and species that actually existed. Recognizable fossil insects thus indicate a reliable, if not a specific, correspondence with then-existing plant relationships and with plant—insect interdependence.

In the light of applied evolutionary principles, the botanical and entomological participants of the Ruby flora give us a glimpse into antiquity that allows us a sharp focus on present phenomena. Our limited picture can only dimly suggest the meanderings of the evolutionary path, the immensity of geologic time involved, and the astronomical numbers of species and individuals that fell by the wayside as links between past and present.

Graph traces evolution of insects from Devonian to Recent geologic periods. The Neoptera group comprises 97 per cent of today's insect species.

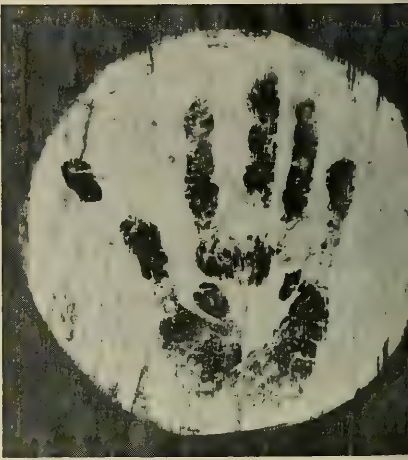


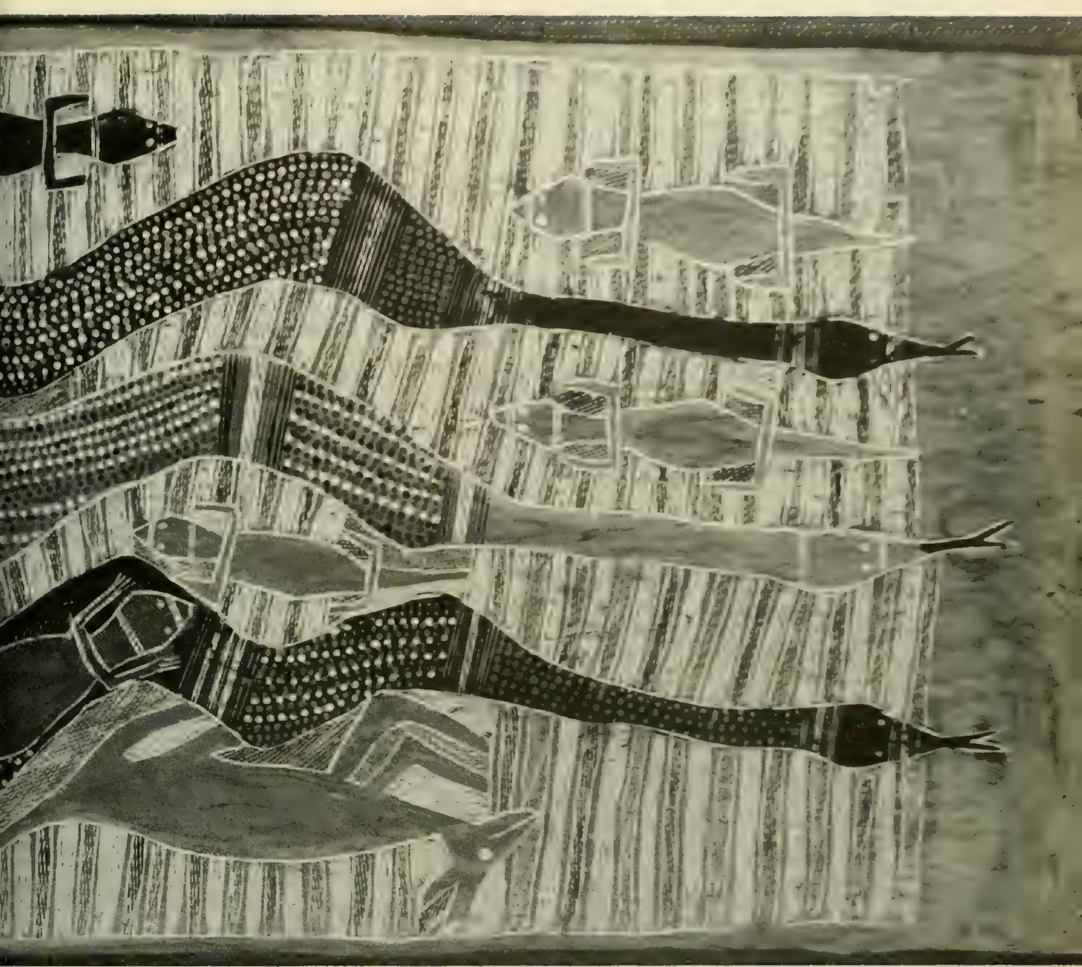


# ABORIGINAL ART AND MYTHOLOGY

## Bark panels reflect clan symbolism

By Stuart Scougall and Philip C. Gifford





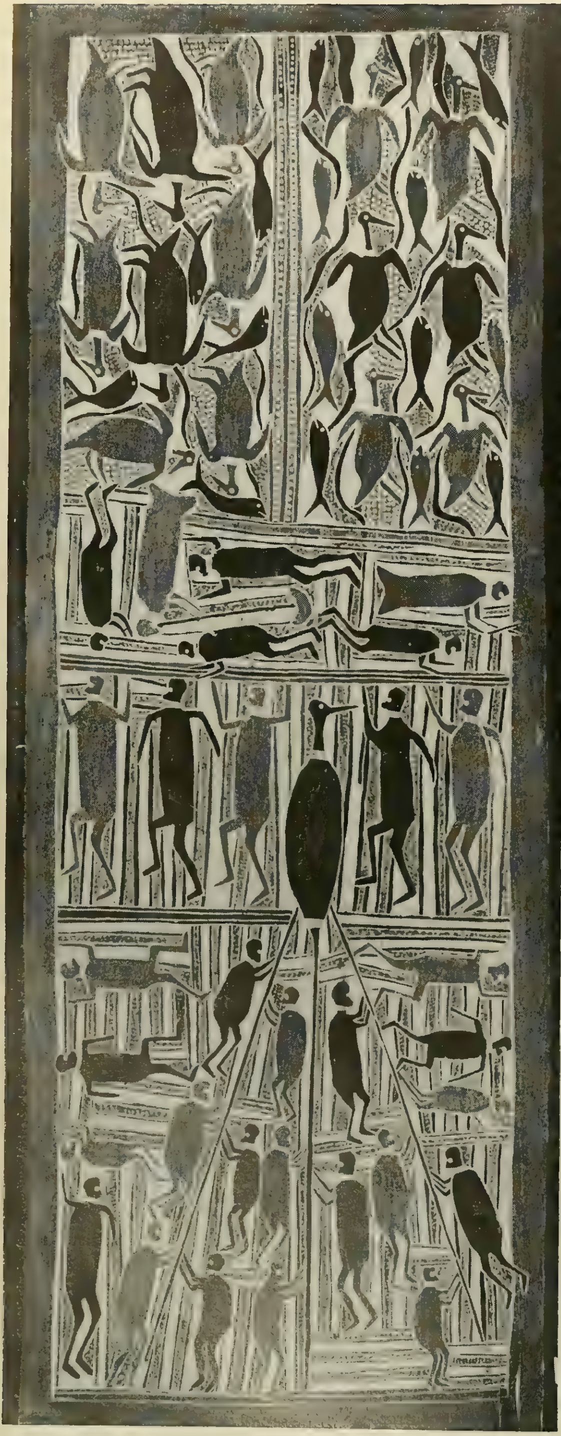
RTIST's handprint is his signature on cks of some recent bark paintings.

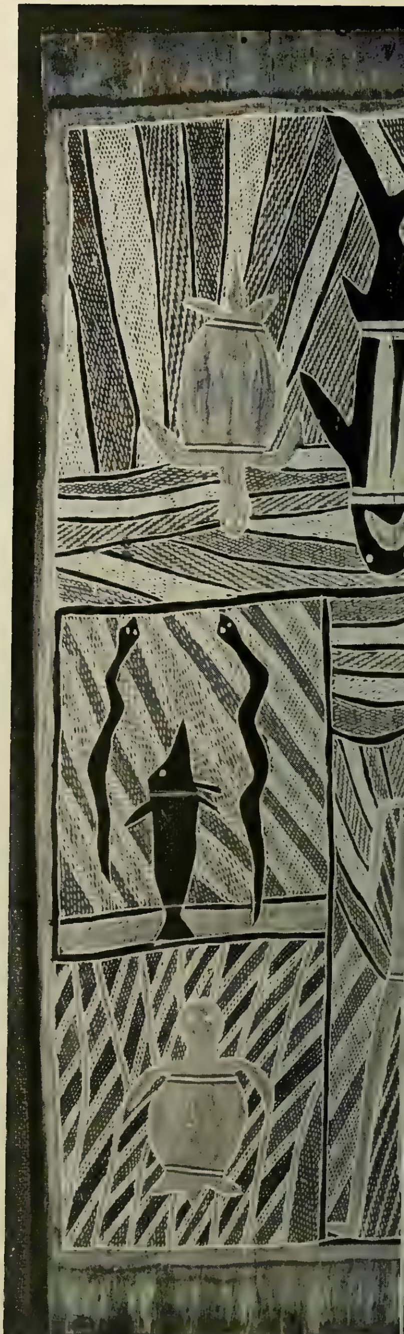
MYTHOLOGICAL scene depicts sources of food: snakes, lizards, and kangaroos.

A racially distinct group among the world's peoples, the Aborigines of Australia migrated across the islands from the north more than 10,000 years ago, spreading to all parts of the continent and exploiting its meager resources of food and water. Today's Aborigines, still moving about their traditional hunting grounds, arm themselves with the simplest weapons: the spear, the throwing stick, and the stone knife. Their "patterned nomadism" is based on expert knowledge of the ways of the animals and fish they hunt, and the location of the vegetables and fruits they eat. They do not till the soil or practice animal husbandry, but they are men and women with centuries of experience that give meaning to their traditions. To call them a Stone Age people may cause us to overlook a significant part of their culture.

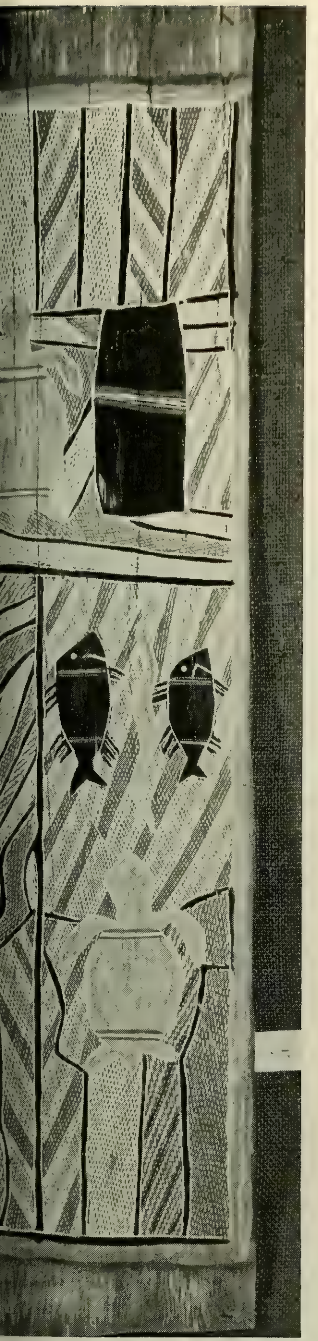
Arnhem Land, a section of the north-central coast of Australia that is the size of Scotland, has been set aside as one of the country's aboriginal reserves. The 4,000 Aborigines who live here have little contact with Western civilization, and among the many interesting features of their way of life, the latest to be studied is their art—particularly their designs painted on eucalyptus bark panels. The contrasting colors and exotic subjects portrayed in their paintings are coming increasingly to the attention of the world public. Arnhem Landers, as well as Aborigines of other parts of Australia, also carve wood, paint designs on the walls of cave shelters, and use painted designs ceremonially on their bodies, but this is the only area where bark paintings are still made.

Three separate styles of bark painting have been developed, and these may be arranged geographically. The main, or standard, style is located in central Arnhem Land and features one or more figures on a plain dark background. To the west, the "X-ray" style





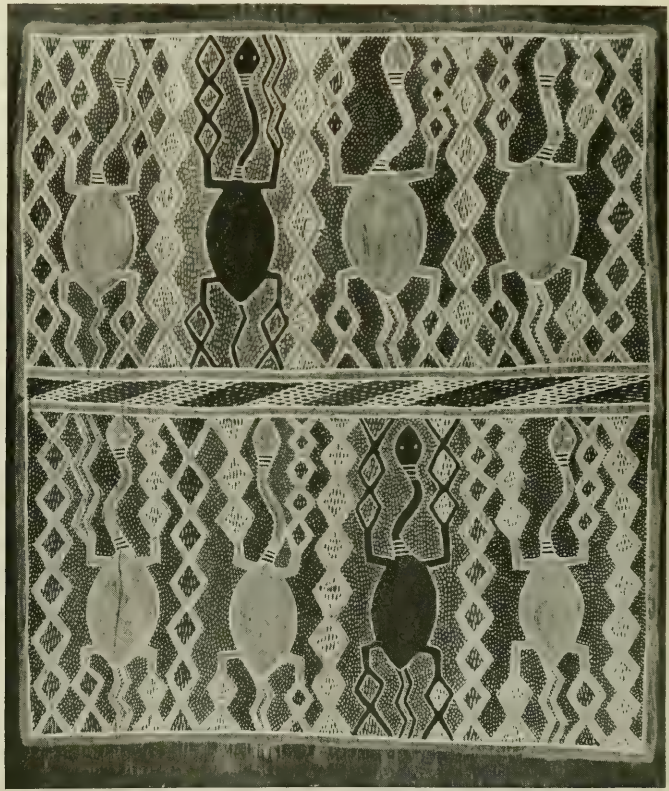
**Ritual** at left portrays birds, fish, dancers, and musicians. Dancers hold their arms in standardized positions.



**JAMBUWAL**, the Thunder-man, stands ith a club in panel above. He is one f the mythological "Creative Beings."

predominates, in which the native artists draw bones and inner organs of fish or animals within the body's outlines. The most complex compositions, however, come from northeast Arnhem Land. Here, drawing covers the panel, and its background is filled and framed with hatched or dotted designs. The arrangement of the delicately drawn, parallel patterns often achieves a somewhat geometric effect. Yirrkala, a location on the coast meaning "running spring waters" in the language of the Aborigines, is a center for this style, and it was here that the illustrations for this article were collected.

Most of the paintings on these pages reflect in some manner aboriginal mythology, which has been developed over many generations and which enables religious values to be attached to almost every facet of their lives. They consider landmarks along the shores—the mouths of rivers, rocky islands, and points of land—as purposely placed there for their use by the "Creative Beings" during the prehuman "time of creation." The products of the sea were also granted to human use, as were the animals and plants of the land. The mythological origin of these landmarks and sources of food and water within a particular clan area is frequently shown in the paintings, as in that at the left. In this picture we see Tjambuwal, the Thunder-man, the source of rain and thunder, standing with his club before a background of characteristically curved lines that represent clouds. Sea animals, available at the time of monsoon rains, surround him. Paintings such as this are typical of the coastal



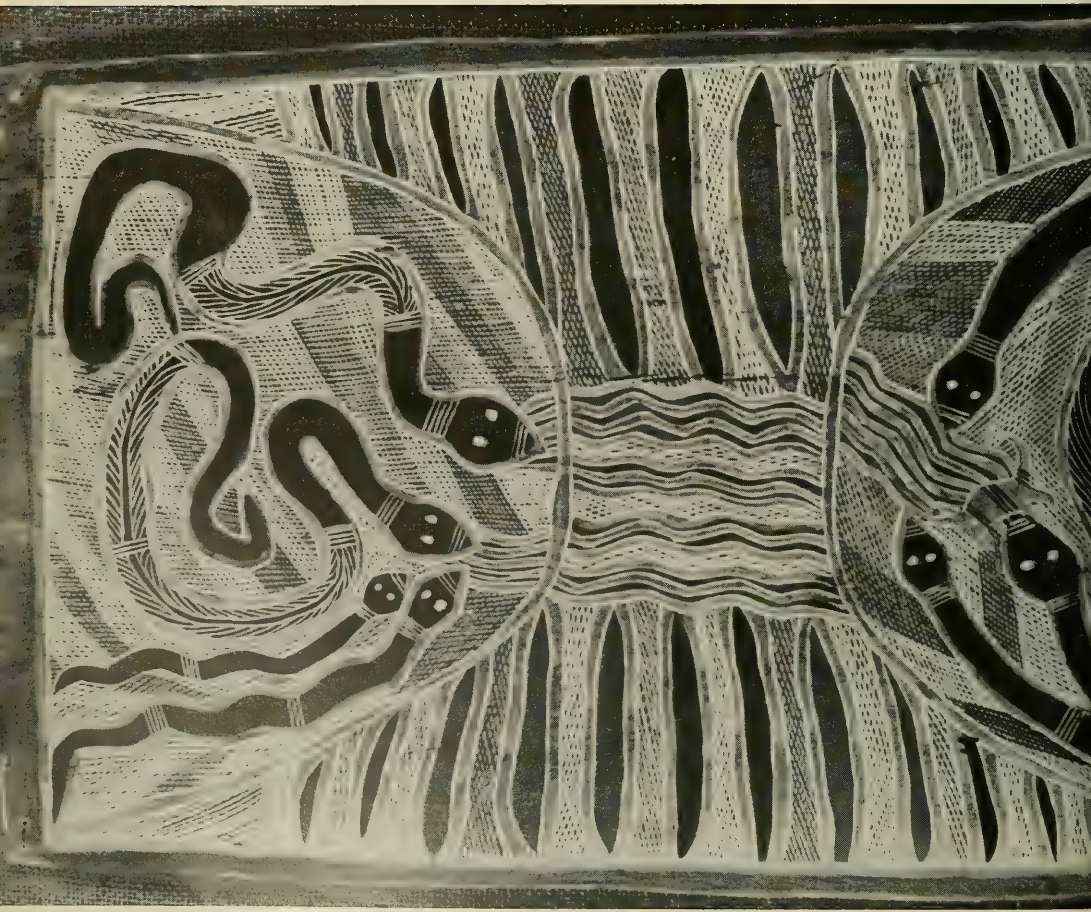
**Turtles**, among the animals placed in the sea during the prehuman "time of creation," swim in a tree-lined swamp.

areas that face the Gulf of Carpentaria and the Arafura Sea.

Arnhem Land has a variety of landscapes: the hilly interior, which is extremely dry except for the rainy season; fresh-water and eucalyptus swamps; and grass-carpeted sand hills bordering parts of the ocean. A considerable number of animals and birds may be found here and are used by the Aborigines for food. Each clan has its own traditional hunting area, and clan mythology centers in that particular section. Although they paint descriptions of places, they are not landscape paintings in our sense, in which sky and trees are drawn with shading and perspective. Rather, the artistic elements of the bark paintings, though not truly abstract, are simplified symbols that have specific, recognizable meanings for the Aborigine. The works are not meant for the casual viewer, and most of them are impossible to "read" without instruction.

As an example, the types of snakes portrayed in Arnhem Land paintings are varied. The snakes used for food often represent a totem place, or sacred locality, where the ceremonies of increase are held. Other snake drawings are associated with the creation of water holes and rivers. Some of these snakes are shown in the sky, where, it is believed, they go during the rainy season. The "lightning snakes" pass from cloud to cloud—often in groups—and the "rainbow snake" may be drawn in an arched position.

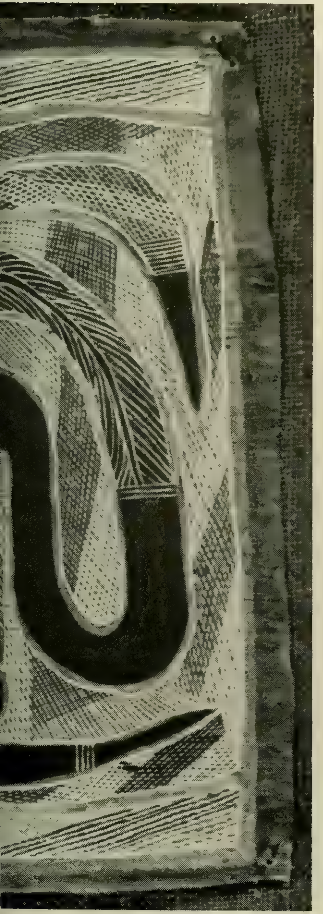
Even the plaidlike hatching in the background is important, as usually it is a clan-owned pattern, which only clan members may adopt. The "plaid" is adaptable, and it may be used uniformly throughout the painting or only to fill in areas that are not colored solid. Parallel stripes in this mode are sometimes understood as waves in a water design, or as rain in a picture representing the sky. A complicated background is shown in the painting of long-necked turtles on page 49, which is made up of rows of connected diamonds, colored alternately black and brown. The diamonds, interpreted as paperbark trees (*Melaleuca*), signify a swamp in which the turtles are swimming. A similar pattern may also be used to designate ashes that cover a burned-over area of land. The right to relate a particular myth, as well as the right to use a background pattern, is



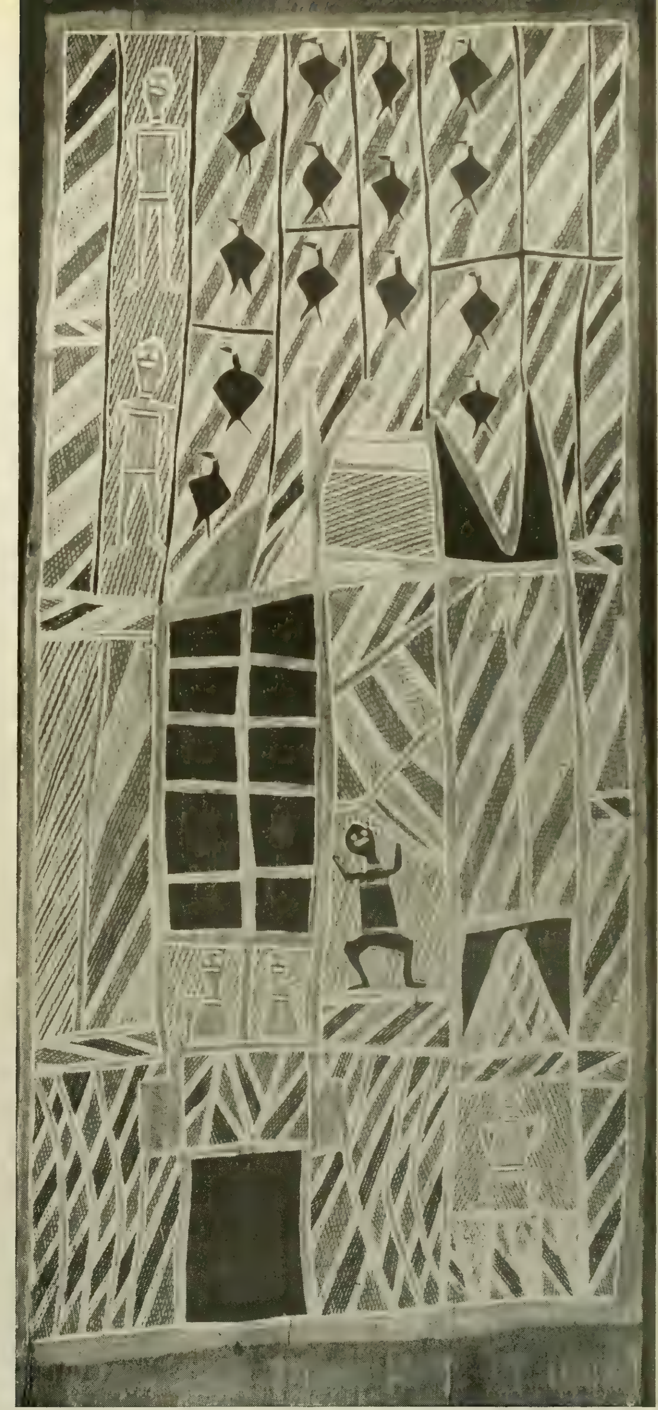
considered to be the property of a clan.

Bark is widely available in Australia. It is used to wrap bundles, to hold food, and to make boats. Although the origin of its use as an art material has been forgotten, it is possible that the Aborigine developed his painting technique during the rainy season, known simply as "the wet," while sheltered in a temporary bark hut or lean-to.

To prepare the panels, the Aborigines strip curved slabs of bark from the stringybark eucalyptus (*Eucalyptus tetradonta*) and steam them over the coals of a fire. After a few minutes, they peel off the outer fibrous surface, place the damp bark sheet on level ground, and cover it with sand to dry it—a process that takes several days. The red, white, and yellow colors in



**Snakes** at left are seen inside their nests near a water hole represented by wavy lines. Snake on right eats a rat.



**Complex** painting above shows a Malay prau and its crew viewed from several angles. Black squares form boat's hull.

the paintings are ground ochers mixed with water or saliva. The black may be an ocher or some compound using carbon. Traditionally, the ochers are not mixed and are applied over a base coat of solid colors. (One contemporary Yirrkala artist, Wandug, now uses an olive color that is black and yellow mixed. The lively fish in the seascape on the facing page are in this experimental color, which other artists are beginning to use sparingly.) The juice of a local orchid may be added as a kind of fixative to prevent the paint from flaking. Chewed twigs or frayed leaf edges make paintbrushes, and fine lines are made either with a feather or with a few hairs fastened to a handle.

The process of painting a religious subject has value in itself as part of a ceremony. The Aborigines believe that relating the clan myth in colors and on bark actually re-creates the portrayed spiritual reality. Some sacred paintings are revealed to initiates as part of coming-of-age ceremonies, and contact with them during the rite is a religious experience for men only; the paintings may not be viewed by the tribeswomen or by outsiders. They represent the continuity of the natural order necessary for the clan to maintain itself as a group. The actual bark and its painting are not felt to be sacred, however, and are discarded.

Other types of drawing are less important ceremonially, although they also may be related to native belief. One of these is shown on page 51. It recounts a mythical incident when Thunder-man dispersed an early, unidentified people during the spiritual "dreamtime" to make the land ready for the Aborigines. The elements of the story are so arranged that one must view them from several angles. The principal feature of the painting is a sailing vessel with its crew. The hull of the boat is a dark, grid-marked rectangle, with the bow toward the top of the picture. (The boat is best viewed from the left side.) The sail is parallel to the hull, with its triangular corners painted black. A tripod mast holds the sail, and the lines of the rigging may be seen. The stern of the boat appears as though viewed from above, with the two steersmen holding their oars. Two other crewmen stand in the top left corner of the painting, and the captain stands alone, hands on hips, in the lower right corner.

The boat and its rigging represent a Malay prau. Malay fleets actually sailed to the north coast of Australia to fish for trepang until sixty years ago, and their boats were incorporated into aboriginal myths as the crafts of a prehuman population. The technique of dispersing parts of the natural order and then regrouping them into a design is a typical feature of Yirrkala art style. In some instances, as here, the background pattern is interspersed within and around the story elements, and the effect is that of a complex abstract painting.

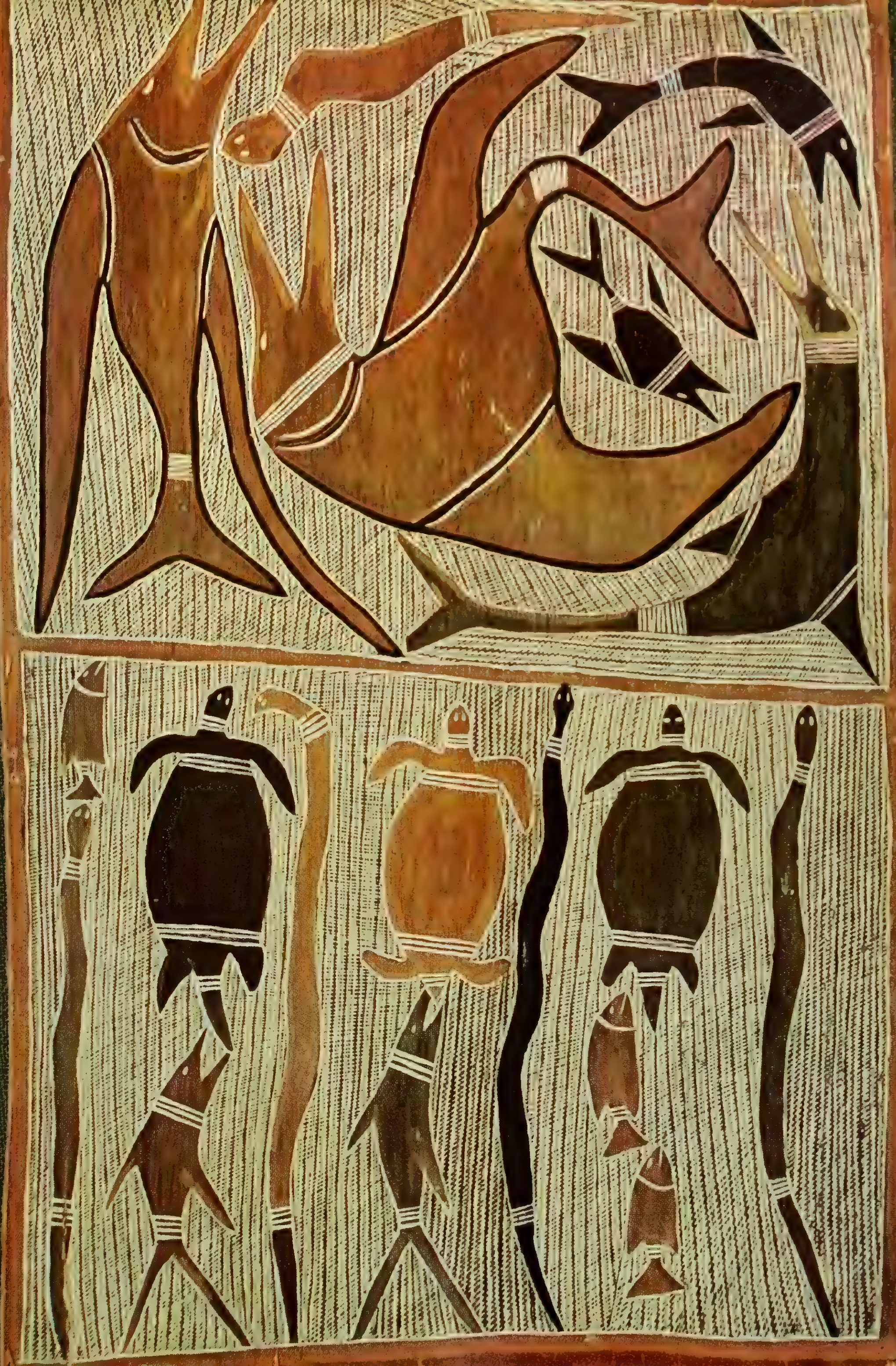
To add to our appreciation, we must consider two important points. One is the nature of the symbols used; the other is the importance of the myth cycles to Arnhem Land Aborigines. We must first remember that the art we see here is a developed system with a long history. Outlines of the fish and animals are not crude or inept, like those of a child's drawing. A fish painting emphasizes specific characteristics that distinguish it as a barramunda instead of as a shark or a ray or some other fish or animal. A symbol is intended, not a detailed drawing. Whatever action, size, climatic conditions, or other information that is necessary to the story beyond the painted symbols is furnished either in a story told by the "song-man" who conducts a ceremony, or in imitative dances. Symbols, once arrived at, tend to be retained and repeated in other paintings. Since the aboriginal artist paints his pictures from memory, he can reproduce simple shapes and designs most easily. In many of the traditional paintings, symbols make up the entire pattern, and they must be held accurately in the mind from one year to the next. Some of the artistic "distortions" and what seem to be products of poor observation can thus be understood. The symbols have a striking effect on the mind of both the viewer and the artist, whose duty it is to remember them.

Patterns of the traditional myths, which bark paintings help to recreate, are connected with the symbol system. Clans in neighboring areas often share "general" creation stories, but individual episodes, such as telling how the mythological Wawalik sisters or Djunkgao and his sister created particular landmarks, are significant only to specific clan areas. Most of these Creative Beings represented in the paintings have strongly developed characteristics that are used symbolically and help to identify them. Tjambuwal, the Thunder-man, is a good example. His totemic place is Jalboa, a point of land on the shore near Yirrkala, and stories of his good offices toward the residents of the coast are popular in the neighborhood. He is represented as a standing figure, usually holding his magic club, which he uses to stun rock cod out at sea. Background patterns of curved lines are thunder clouds when associated with this figure, and he is often shown urinating—the source of rain. In the painting on pages 48-49, diagonal rain streaks are indicated between his legs. In a sense, an aboriginal painting is a formula, made up of graphic elements in which the story is made visually evident. The particular elements and their combination, however, are not "explained." An artist may draw the same figure to represent Tjambuwal in any of the several stories concerning him. Thus, to interpret fully such a multipurpose symbol, the artist's own statement of purpose is essential.

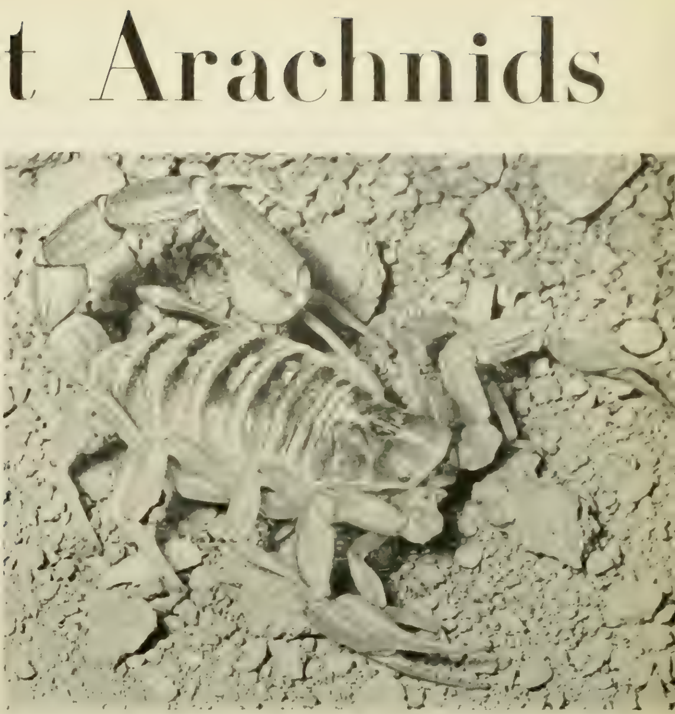
During the last decade, several extensive scientific collections of bark paintings have been made, and detailed information has been recorded for each panel. With the use of recently developed plastic sprays and laminated backing to prevent wear and warping, the paintings, which would ordinarily have had a short life, now form a valuable record of the artistic capability of this people and the way their styles have developed. As more painting is done for non-ceremonial purposes, larger and more ambitious pictures have appeared, which may include many figures.

Traditionally, any male Arnhem Lander is capable of making a bark painting. The experience of its construction is one part of his powerful art tradition, which includes chants and the dance, that brings the distant past into the immediate present. The skilled aboriginal artist, working with his limited materials and with a system of symbols that are personal to himself and to his group, creates what we must consider a valid art form. He achieves in the bark paintings a remarkable synthesis of belief and experience that is most certainly worthy of attention.

**Colors** are usually pure ochers, bu
the olive in this panel is a mixtur



# Desert Arachnids Emerge



**Young scorpions** pictured at left are about two weeks old and are gradually changing color from white to pale tan.

**Gravid female** was photographed two weeks before giving birth, after which the body resumed usual flat appearance.

## The greatest danger to newborn scorpions may be their mother

By Robert H. Wright

A fascinating phenomenon in itself, the birth and early life cycle of the scorpion becomes even more remarkable when one realizes that the basic characteristics of this arachnid have remained virtually unchanged over hundreds of millions of years, making it the oldest true arachnid.

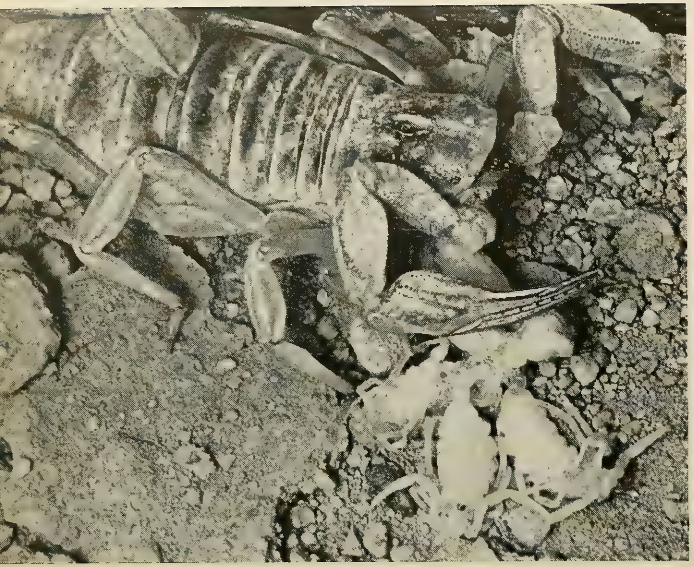
Scorpions were already in existence in the Silurian Period (400 million to 425 million years ago), and although they were still aquatic during this time, fossil records have revealed no dramatic structural differences between the ancient forms and those of the present day. While behavioral characteristics vary to some degree among different families and species of scorpions, the birth sequence of the *Hadrurus arizonensis*, found, as the name implies, in Arizona and pictured on these pages, is generally representative.

The mating of *Hadrurus* is characterized by an elaborate courtship dance in which the male lays a strikingly contrived spermatophore on the ground, then pulls the female across it so that the spermatophore becomes inserted in her genital aperture at the base of the abdomen. The courtship sometimes ends abruptly with the female devouring the male.

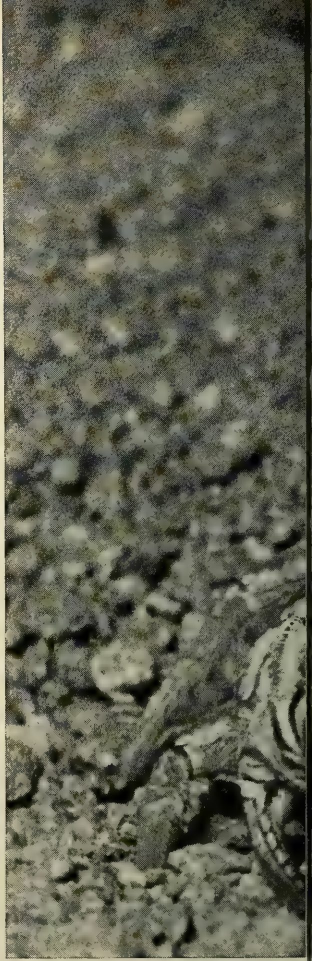
Once fertilized, the eggs develop inside the female. The course of development may vary among species, depending on the richness of the egg yolks. The rate at which the young are expelled from the genital pore also varies; in the case of the particular *Hadrurus* pictured here, two or three young were born at intervals of twenty to forty minutes, a total of eighteen over a period of five hours. At birth, the young average three-eighths of an inch in length and, completely white except for their eyes, resemble maggots. When they emerge, they are encased in a thin membrane, or amniotic sac, from which they must wriggle loose. If the mother happens to be hungry, the young may meet the same fate that befell their father. In the litter shown here, three out of eighteen failed to free themselves before they were devoured.

Those that are successful in struggling free proceed to climb onto the mother's back. This may take two or three hours, since the young are weak, plump, and move slowly. After they have executed the climb, they remain there until they can shift for themselves. Depending on the species and the climate in which they are born, the young may stay on the mother's back from ten to sixteen days. During this period, their food comes from yolk materials retained in their bodies.

The young scorpions undergo incomplete metamorphosis; their growth and change is accomplished through a series of molts. After the first molt they acquire recognizable scorpion appearance, after which they remain with their mother for one or two more days before they strike out on their own.

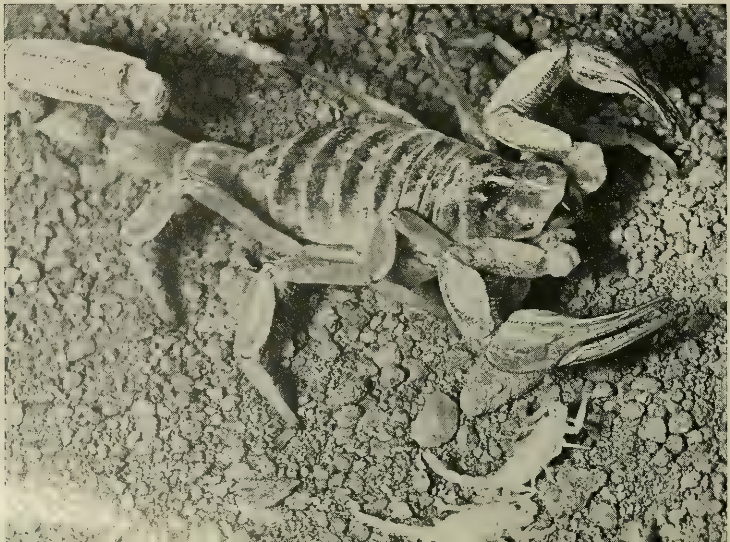


**Hour-old scorpions,** *above,* have freed their legs from the amniotic sac. The tails are still tangled in the membrane.

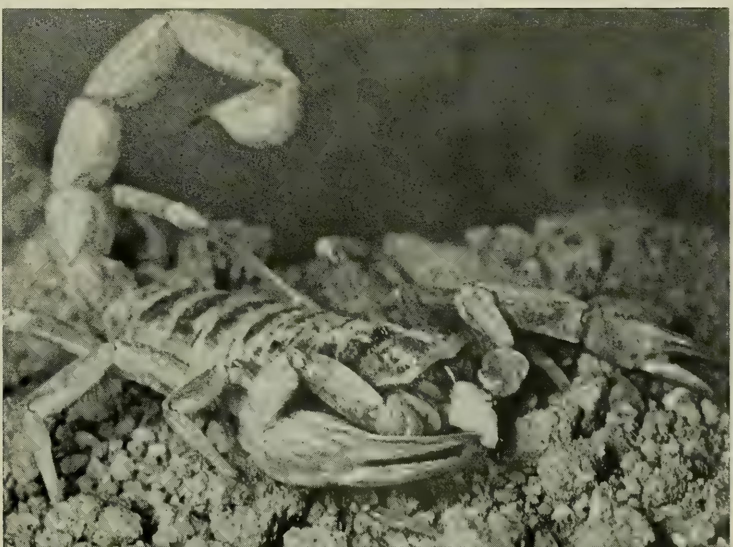


**Mouth of adult,** located between front pinchers, consists of small, clawlike structures that pull in and mash food.

**Two newborn scorpions,** *below,* were the first of a litter of eighteen that emerged over a period of about five hours.



**Mother is devouring** one of her young, *below*. Three of the litter were eaten before they were free of the amniotic sac.



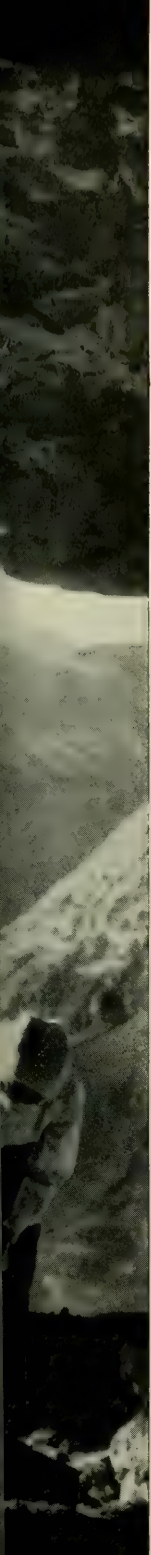


PHOTO COURTESY ISRAEL GOVERNMENT TOURIST OFFICE

# IBM computers help men find secrets in scrolls, history in the stars– and answers to literary puzzles

IN 1947, an Arab boy searching a cave for a goat stumbled upon the first Dead Sea Scrolls. They were in tatters when scholars received them. Words, even whole sentences, were missing.

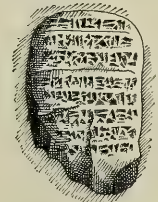
Scholars used an IBM computer and "crossword puzzle logic" to test thousands of combinations of words until they found the best-fitting meanings.

Further computer work on the Scrolls has helped shed new light on Biblical times, and the use of language 2,000 years ago.

Recently, IBM computers have helped scholars explore other fascinating subjects.

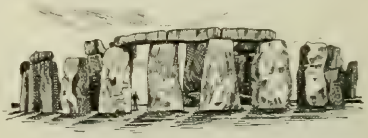
**Books of clay and IBM computers**

The drawing below shows one of many clay tablets on which ancient Babylonians wrote their history. Scholars could read them, but could not easily date them.



Then an IBM computer was used to chart the movements of planets over Babylonia from 600 B.C. until 1 A.D. These planetary tables could then be compared with observations of the heavens Babylonians had marked on these tablets. It is now easier to place six centuries of history in proper sequence.

Stonehenge, a huge monument in England, has mystified men for centuries. *What in the world was it for?* Recently, scholars gained a new theory as to its purpose. With the help of an IBM computer, they analyzed the curious placement of its stones.



The research showed the stones could have been used to "sight" the sun and moon *3,500 years ago*—to predict seasons and even eclipses with reasonable accuracy.

**Helping solve literary puzzles**

There are many unanswered questions about world literary figures, from Yeats back to ancient Homer.

Using IBM computers, scholars are getting many new perspectives on the work of these men. Disputes about who wrote what are being settled. Literary indexes that once took tedious years to complete can now be finished in weeks.

*Computers are helping man fill in blank pages of his past, to gain a new understanding of that fascinating subject—himself.*

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# About the Authors

Dr. Gilbert Gottlieb, author of "Components of Recognition in Ducklings," received his A.B. and M.S. degrees in psychology from the University of Miami and his Ph.D. from Duke University. From 1959 to 1961 he performed animal behavior research and practiced clinical psychology at Dorothea Dix Hospital in Raleigh, North Carolina. He has now turned solely to research at the hospital, centering his studies on the prenatal aspects of behavior in birds, particularly the development of sensory organization. Dr. Gottlieb is also Assistant Professor of Psychology at the University of North Carolina and is editor of the comparative behavior section of *Biological Abstracts.*

Nancy Flowers, a free-lance writer and photographer, wrote the article on Portuguese boats and took the accompanying photographs. She has traveled throughout the world since childhood, living on Madeira during World War II and in Portugal for the next ten years. Her interests include the social and economic problems of developing countries, maritime history and the history of exploration, and Portuguese and Brazilian folklore and folk art.

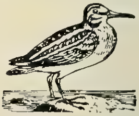
"Ears of Dipodomys" was written by Dr. Douglas B. Webster, Assistant Professor of Biology at New York University. Dr. Webster received his A.B. from Oberlin College, his Ph.D. from Cornell University, and was a Postdoctoral Fellow at the California Institute of Technology from 1960 to 1962. His research interests include morphology and the adaptive value of specialized structures in desert rodents, and the functional morphology of the brain.

"Flowers, Insects, and Evolution" was written by Dr. Herman F. Becker of The New York Botanical Garden. Dr. Becker received his A.B. from Brooklyn College, his M.A. from Columbia University, and his Ph.D. in paleobotany from the University of Michigan. He has taught at Brooklyn College and the University of Michigan and is now conducting research in paleobotany under a National Science Foundation grant.

The late Dr. Stuart Scougall, an orthopedic surgeon of Sydney, Australia, became acquainted with aboriginal art while engaged in a study of the body mechanics of the Aborigines. His interest stemmed from the one-footed stance of the aboriginal hunters. Dr. Scougall gathered contemporary bark paintings for exhibition throughout the world and helped to publicize this unique form of art. Following Dr. Scougall's recent death, Philip C. Gifford, Scientific Assistant in The American Museum's Department of Anthropology, completed the manuscript for publication.

Felis leo

Clupea harengus



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# nature and photography

## a planned approach to zoo movies

### by Sam Dunton

Back in the Roaring Twenties, and even into the early thirties, it was a courageous individual indeed who attempted amateur movies of any sort. Seldom were motion-picture cameras seen in a zoological park unless they were the ones operated by newsreel cameramen or other producers of professional films. Now, but a few decades later, the amateur photographer's sun has risen in great brilliance, and we are inevitably enmeshed in the era of the "Big Picture."

Thousands of feet of color film are exposed annually by visitors to the large zoological parks and smaller zoos throughout the world; as Staff Photographer for the New York Zoological Society, I have had the pleasure of examining a substantial sampling of amateur zoo filming. Much of the footage I have viewed has been very good, but a considerable amount could have been improved immeasurably from an aesthetic viewpoint. Some of it failed to be even a practical representation of what the photographer had seen.

Today, with the technical advantages of automatic exposure control, battery-driven motors, and relatively inexpensive telephoto lenses of good quality, the average amateur *should* be able to concentrate on the aesthetic value of his filming; unfortunately, many do not. Too often the regal stature of a lion, the graceful carriage of a gerenuk, or the ethereal beauty of an egret is marred by encroaching bars or wire screening. Even when such obstructions do not appear directly in the picture, their shadows may cast disfiguring patterns across the animals. Glass-fronted cages with a high level of lighting present somewhat less of a hazard, but considerable care must be used in angling the lens to keep the photographer's reflection from intruding into the picture area. A polarizing filter will help in some instances, but the attendant increase in exposure often

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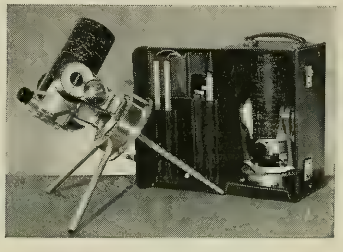

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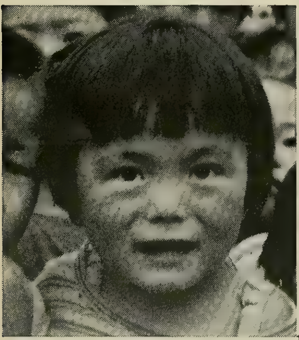

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prevents its use. In most instances a careful choice of camera angle will suffice.

## The Mind's Eye

APPARENTLY, most persons viewing the exhibits at a zoo never really see such obstructions, but see past them, their vision concentrated on the animals. Unfortunately, the camera lens will not duplicate this feat, for while human vision is binocular, the motion-picture camera is monocular, and footage that is shot without consideration of this fact is apt to show a great detail of wire mesh or bars and very little of the animal.

It is difficult to excuse the constant repetition of such mistakes by individuals of accepted competence. One photographer I know spent most of his spare time at the zoo, taking picture after picture of all kinds of animals without ever realizing that most of his efforts were worthless because of the predominance of wires and bars. He came to my office one day with a dozen Ektachromes of three tiger cubs. He was as pleased as Punch because the color was good, but quite unaware that the transparencies were marred by a pattern of wire mesh. To show him the error of his ways I took him into the projection room and screened a recently completed movie showing these same three cubs romping and playing, with no evidence of unsightly wires anywhere in the picture. The film clip finished, I sat back to await his inquiries as to how I had managed to avoid the wire.

"Say! That's quite a film!" was his only comment, and then, apparently as an afterthought, "Cute little fellows, aren't they?"

Actually, there is no magic formula to "make the wires and bars disappear." The photographic emphasis should be placed on avoiding situations where they occur, and one's photography should be concentrated in the many areas available in most zoos where such obstructions are at a minimum. Where it *is* necessary to photograph into a barred or wired cage or enclosure, it is often possible to angle a telephoto lens in such a manner that one just misses the inclusion of bars or mesh. In areas where security regulations permit, a telephoto lens of at least three times the length of your normal lens can be placed within an inch or two of fine mesh wire, and if an aperture no smaller than f/4 is employed, the mesh will be so far out of focus as to be entirely invisible in the finished film. Obviously, the subject should be at some distance from the camera when this technique is used, so that the focal plane is as far removed from the wire as possible.

There are two standard methods of approach to the making of good motion pictures of animals in the average zoo. One is to walk slowly through the

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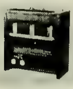

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grounds and photograph at once any interesting action occurring at the moment in well-lighted locations with good backgrounds. The other is to make the acquaintance of the keepers and enlist their aid in obtaining specific results.

Either plan works. I knew of one advanced amateur who practically made a career of getting to know Bronx Zoo curators, keepers, and any and all personnel who might help him to arrange his subjects. Some of his pictures were excellent. I knew another amateur who spent every Saturday morning roaming the zoo with his camera. He never asked for special favors and carefully observed all the visitor regulations. His pictures were outstanding and won many awards.

### Anticipation is Key

No two animals are exactly alike in respect to temper and temperament, and this makes it difficult to set up hard and fast rules for photographing them. Probably the best procedure for anyone concerned about making outstanding motion-picture footage in a zoo is to walk through the grounds slowly, with the camera "at ready." Spend a little time at each exhibit just watching the animals. If the action—and background—looks good, photograph it! If not, make a note of the location and the lighting available at that time of the day and go on to some other enclosure to follow the same procedure. At another time, conditions may be entirely favorable in the exhibits you have passed by.

Don't feel that you are at a disadvantage because you must photograph from outside the enclosures. Most professionals work the same way, for there is not as great an advantage to be gained by entering a cage or enclosure as you might think. Zoo animals are accustomed to a definite spatial relationship to the visitors, as defined by the cage bars or enclosure walls, and you can often approach within a few feet as long as they are separated from you by their familiar physical barrier. I have been able to place my camera within twelve inches of penguins in an outdoor, fenced enclosure. However, once I entered the enclosure I was unable to get within twelve feet of them before they dived into their pool in great alarm. I had penetrated their first line of defense!

The New York Zoological Society had plenty of room at its disposal when it created the New York Zoological Park—better known, perhaps, as the Bronx Zoo—in 1899, and it provided generous ranges, corrals, and exhibition areas. In such surroundings the animals may be seen and photographed in a reasonable facsimile of their native habitats. Our African Plains exhibit is an example, and its success is such that in the near future it will be extended in size and scope to include an even greater range

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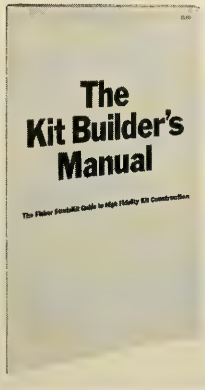
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During the past year one of the oldest exhibition enclosures in the Zoological Park, the big outdoor flying cage, was transformed and augmented in display value by the installation of an attractive promenade where the visitor can walk through the central portion and view avian life at very close range. The birds soon became accustomed to this invasion of their private preserves; they accept visitors completely and go about their normal activities of swimming, feeding, and nest building undisturbed, because the "intruders" are always in the same location, although within the cage.

A Children's Zoo is a likely location for "serious" photography, for the relationship of children and animals has always interested students of psychology. Motion-picture studies of small children and their reactions to various animals (best taken with the camera far enough away so that it is not a distracting element) can prove a fascinating study that could form the basis for a really extended film treatment.

## Tips for Scenarios

UNUSUAL opportunities for amateur motion pictures constantly crop up in any large zoological park. For instance, an animal alphabet film can be as simple or as complex as you wish to make it. Most large zoos have an aardvark—or at least an aoudad—and virtually all have zebras, so at the outset you have material for an opening scene and a final fadeout. Another hint: *Xenopus*, the African clawed-toad, can usually be found in a large collection of reptiles.

A film treatment of such subjects as the locomotion of birds or mammals can be accomplished by anyone willing to do a little research prior to shooting, and films on such vital aspects of animal life as sleeping, feeding, or defensive and aggressive behavior could be challenging.

No matter how you approach zoo photography, caution should be the watchword. And caution should embrace not only the care of your equipment, but your personal welfare as well. Few zoo animals are really tame, and none is

MR. DUNTON, who is a director of the Biological Photographic Association, Inc., serves as the Staff Photographer of the New York Zoological Society.

entirely predictable. Signs that advise you to "keep back" really mean what they say, and are posted at certain exhibits to protect you. Always consult a keeper if at any time you wish to place your camera in such a position that it might violate regulations of the zoo. The keepers, too, are often able to supply you with information regarding the optimum times for photographing the animals in their care, and these individuals know from experience when their charges are active and alert.

It might appear trite to urge the use of a tripod for motion-picture photography, as this is a point that is stressed in virtually every photographic manual. Yet, it is an anomaly that most amateurs at the Bronx Zoo using still cameras equipped with telephoto lenses use tripods, while those with movie cameras seldom do! Beware that attractive pistol grip on your 8 mm. camera. It is a handy device for picking up and carrying the camera, but for really steady pictures one should use a tripod wherever possible. Beware, too, the "zoom" capabilities of the popular variable-focus lens. Certainly, it is a useful device, but the continuous use of its zoom effect can prove to be a most distracting element in the finished film. And unless it is a really costly lens, it will not provide the critical sharpness—so essential in good photography of animals—that a conventional lens of non-variable components provides.

Yes, motion-picture photography at the zoo is a fascinating pastime and a rewarding hobby, and by utilizing a sensible approach, with careful observance of the technical requisites of good photography and with appropriate attention to the aesthetic quality of your footage, you can produce films of enduring quality and high intrinsic value. It is hoped that the suggestions and admonitions set forth in this article will help the reader toward the accomplishment of this pleasant and rewarding objective.

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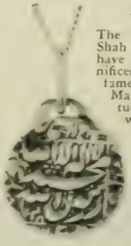

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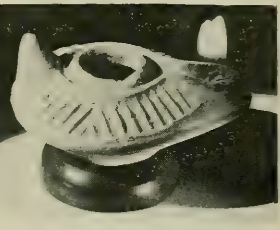

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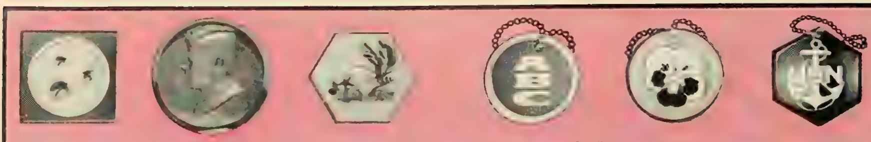

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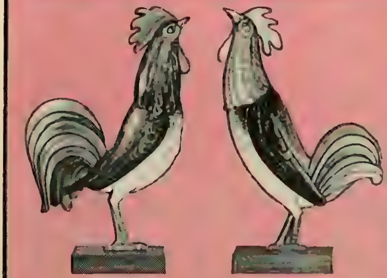

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# The African poison test

### By Merlin Ennis

A visitor to Angola today will find a country deeply involved in serious political and social upheaval, a land where age-old customs often obstruct the inroads of modernity. When I went to Angola in 1903, traditions were already giving way, and yet, during my stay, I was exposed to many fascinating practices. One that has remained with me most vividly over the years is the ritual of the African poison test.

The poison test was once widely used throughout the African continent. Among the kingdoms of the Ovimbundu in the highlands of Angola it was equivalent to a Supreme Court decision. Ordinary disputes were usually handled by a "people's court" where the contending parties presented their evidence and argued over the principles involved. A settlement was usually handed down after general agreement among tribal authorities, but when a case could not be resolved, one of the contestants might appeal for trial by poison. This final trial was conducted by the king, and it was a matter of life or death.

In order to understand the character and finality of this test, one must keep in mind that to a duly installed African king were attributed magical powers and divinity. The Ovimbundu believed, for instance, that their king had control over the weather. When a king died, all fires in the country were extinguished, then kindled afresh from a new fire furnished by the new king after his installation. When a king of the Ovimbundu traveled, he was preceded by a herald and was carried in a palanquin. The herald sounded a gong and blew a whistle to warn ordinary mortals to get off the path and move upwind, lest the effluvia emanating from the royal person should cause them harm. It was universally accepted that a gourd of beer magically charged by a king could discriminate between contending parties who drank it, proving harmless to the innocent but deadly to the guilty. This popular confidence in the king's magical powers made the poison test valuable for settling disputes and promoting harmony.

The beer used in the poison test was like nothing from Milwaukee or Bavaria; it was an opaque, turbid liquid made from a thin, watery gruel that had been soured. The two sides of the dispute having been presented to the king, he would take a gourd of beer duly and magically charged, put magic powder in it, stir it with the royal finger, and give it to one of the principals. This litigant would take a drink and hand the gourd back to the king, who would stir it again with his finger and give it to the other principal, who in turn would drink. To the beating of drums the two would dance until one of them fell down and died, obviously proved guilty.

## A Visit to King John

ALTHOUGH white men heard of it, no white man in Angola, to the best of my knowledge, ever saw the poison test administered; the Ovimbundu were too careful for that. But late in 1903 I had the opportunity to learn more of its "magic" properties. I had recently arrived in Angola from the United States to begin work as a missionary under the American Board for Foreign Missions of the Congregational Church. The American Board was still pioneering in Angola, and had established its second station at Kamundongo in Viye, about 350 miles

**ANGOLAN at the left testifies before a "people's court" in this 1903 photograph.**

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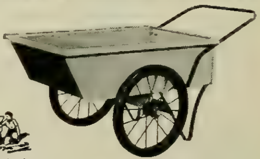

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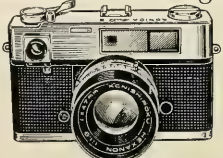

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REV. MERLIN ENNIS died recently. In 40 years as a missionary, he helped introduce new agricultural ideas to Africa and established many schools.

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east of Benguela. The people here were Ovimbundu, their language Umbundu. I was sent to Viye to assist Dr. Frederick C. Wellman, an experienced missionary and a brilliant man with a flair for learning languages quickly.

Viye was one of the chief native kingdoms of Angola. The Portuguese carelessly spelled its name either Bié or Bihe. For some reason, in extending their civil control over the area, the Portuguese had recently exiled the native king of Viye to the Cape Verde Islands. Then, not realizing that among the Ovimbundu in Viye the kingship was elective, they assumed that it was hereditary. Wishing to have a pliant native authority to deal with, they sought out John, the son of the deposed king by a slave woman, and proclaimed him monarch. John went to the king's capital, took possession of the royal regalia and magical equipment, and retired to his village, some forty miles away. It was here that Dr. Wellman and I visited him.

After we had come into the royal house and were seated, we were greeted ceremoniously by the king according to the custom of his people; he expressed his happiness over our visit, and said that as an indication of his pleasure he was presenting us with a fowl, which was at the door. When we went to the door, we saw that the "fowl" was a sturdy three-year-old bull. This was in keeping with Ovimbundu etiquette, since they were masters of the understatement. Calling a bull a fowl was the king's way of deprecating his gift.

Dr. Wellman had learned to speak Umbundu and to understand the customs of those who spoke it, so he knew how to deal with a fowl of this size. If he had taken the bull, the king would have returned our visit expecting a larger fowl in return. So Dr. Wellman admired the animal and offered thanks in proportion to the greatness of the gift, but said that he had a request to make. The king said, "Make it." Then the doctor explained that we were traveling light, and it would be a kindness to us if the Ovimbundu would care for the fowl until we returned. The king considerately agreed to this. Each of the two knew that this ended the matter.

## Unerring Justice

As we continued talking, Dr. Wellman mentioned the poison test, and the monarch offered to demonstrate for us how the magical discrimination between guilty and innocent was worked. He went into another room and returned with all the paraphernalia except the beer. First he exhibited a large gourd used for holding the beer, and a long, slim-necked leather bag made from material resembling buckskin. Although it was slightly larger, the bag looked like the shot pouch used with old-fashioned muzzle-loading guns. He then pointed out a detail that onlookers could not have distinguished: the bag was double, as was the neck that led from its two pouches.

King John explained that in one side of this double dispenser was a light-colored, inert powder. The other side contained a poisonous powder of similar appearance. He then took up the gourd and, pretending that it was two-thirds full of beer, pinched shut the opening on one side of the double leather bag, poured some of the harmless powder into the gourd, and went through the motions of stirring it with his finger. Then, taking the gourd in both hands, as Ovimbundu etiquette required, he went through the motions of presenting it to the first litigant. The person receiving it would drink from the gourd and hand it back to the king. The recipient of the harmless powder, of course, would be proved innocent.

Then the king pinched shut this "outlet of innocence," and from the other outlet poured some of the poisonous powder into the assumed beer, validated the charm by stirring with a finger, and went through the motions of presenting the gourd to the second litigant. He, too, would drink and give the gourd back. As the contenders danced to the drums, this second man would fall and be judged guilty.

This was only the first part of King John's demonstration. He next exhibited another powder that he said was poisonous, heavy, and not very soluble. When this powder was put into the beer it would sink to the bottom. The king would stir only the surface of the liquid before presenting it to the first drinker. When he had drunk, and the gourd had been returned, the beer would be stirred thoroughly from the bottom. The second man would take the gourd, drink the "spiked" beer, and start the dance of death. This would continue until the verdict was rendered.

After exhibiting these two methods of dispensing justice by his divine magic, the king brought out a ball of translucent gum. He worked this with his fingers into a thin, plastic-like wafer. He put a small quantity of another powder upon the center of the wafer, which was then attached to the inside wall of a dry gourd. In this way the poison was contained between the gourd and the wafer. This procedure had to be done in advance. At the time of the trial, beer would be poured into the gourd. When the ceremonies were complete, the king would take the gourd, stir the surface of its contents lightly in the center with the tip of his finger, and give it to the first man. Before the second man drank, the king would stir deeply next to the outside, taking care to remove the wafer from the gourd wall with his fingernail, thus releasing the powder into the beer. The victim would drink and be convicted.

Dr. Wellman asked: "If a mistake should be made in administering the poisoned beer, what would happen?"

John smiled and said, "Kings do not make mistakes." He then explained some of the administrative values of his judicial procedure. If there should be a troublemaker in the kingdom, or a personal enemy of the king, the monarch would encourage some henchman to pick a quarrel with the undesirable citizen and then challenge him to the poison test. The king would attend to the rest. There would be occasions when the person who was asked to pick the quarrel might also be in disfavor. In that event there would be a double funeral. A firm popular belief in the validity of a poison test was useful to the throne and helped to stabilize the kingdom.

### The End of Magic

Long after our interview with King John we wondered why he had chosen to reveal these mysteries—the invaluable props of his kingship and his divinity—to two white men on a casual visit. Our answer was a web of several strands. He was an intelligent man who realized that the beginning of the twentieth century was the end of an era of native independence in Angola. The Portuguese, who had placed him on the throne, forbade him to use the poison test as a judicial procedure. He knew, as the Portuguese did not, that although he was the son of a king, his birth to a slave mother had made him ineligible to the kingship, and that since he had not been duly installed and consecrated, his people would never believe him to have magical attributes or accept him as monarch. I would like to think, too, that he considered us friends, and wanted us to realize that old customs among the Ovimbundu had values, even though we taught other ways.

I left Viye after eighteen months to work in a distant part of Angola. Some time later I learned that the Portuguese had removed John from his throne. The era of magic-working kings had ended.

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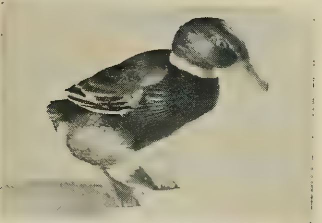

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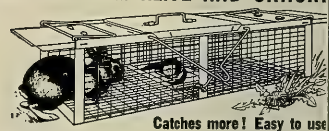

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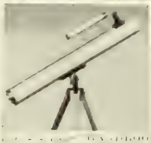

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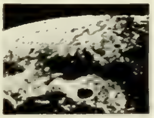

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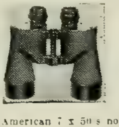

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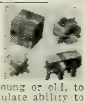

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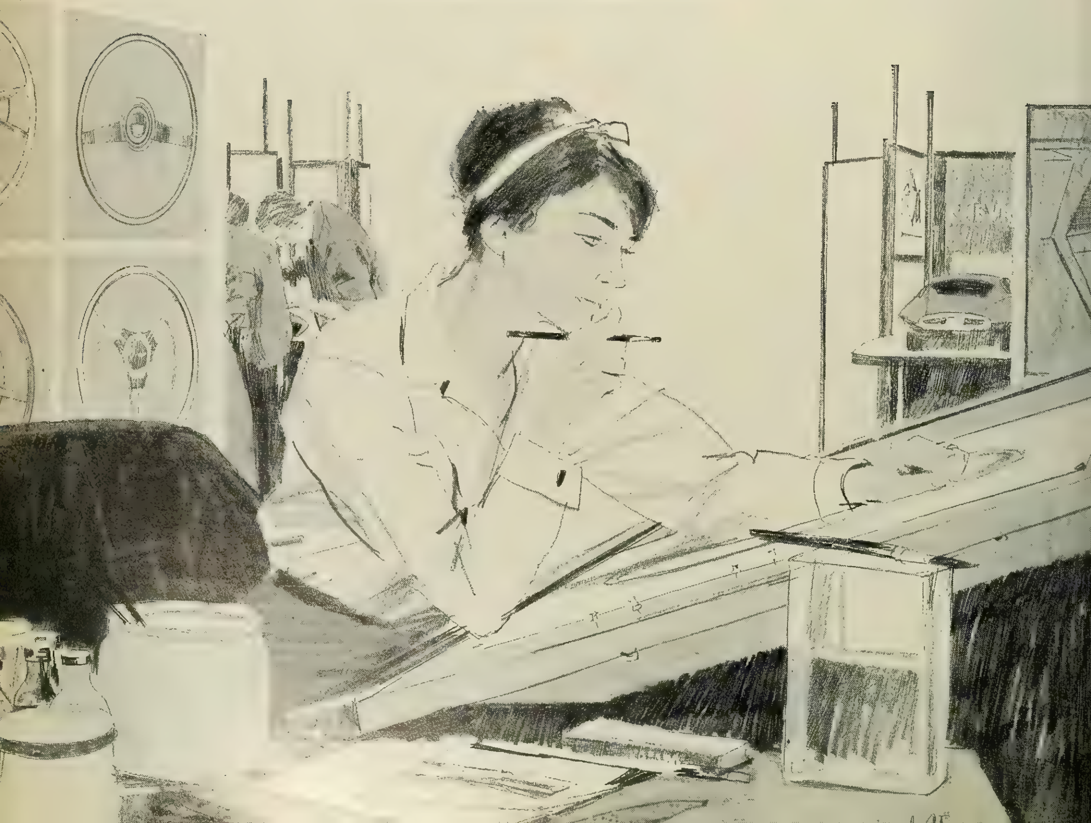

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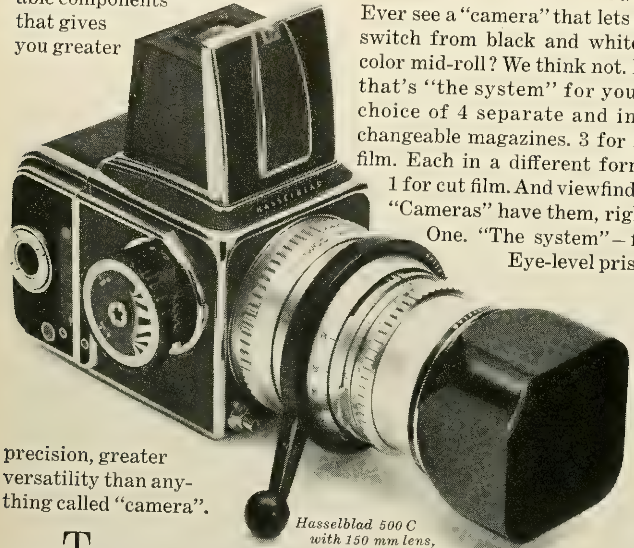
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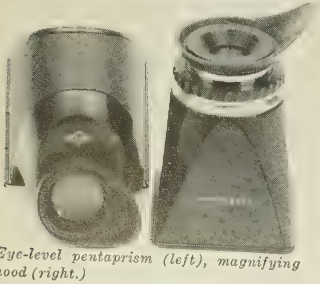
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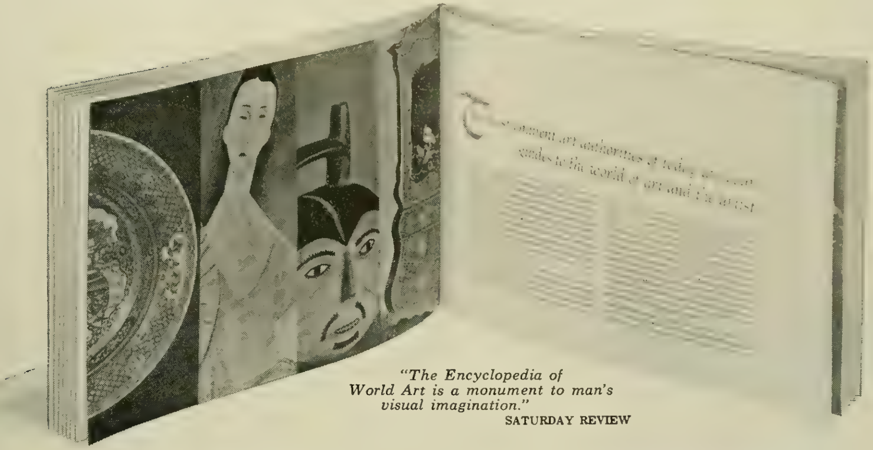

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# Natural History

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*THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY*

Vol. LXXIV MARCH 1965 No. 3

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COVER: The Kofyars of northern Nigeria have displayed ingenuity and tenacity in adapting their methods of agriculture to a difficult environment. Protected from conquest and change by the steep, rocky hills of the Jos Plateau, these hill dwellers have farmed their broken land for hundreds of years, developing techniques that are highly regarded by experts of today. The cover photograph, taken by Dr. Robert M. Netting, shows a Kofyar family threshing millet, one of their principal crops. They pound the grain in tree trunk mortars. Beginning on page 14, Dr. Netting discusses the Kofyar method of feeding a dense population.

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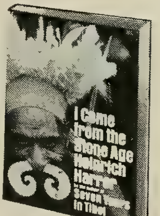

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BOOKS / IN REVIEW

# A gallery of antiquity

### By Harry Bober

THE BALTS, by Marija Gimbutas. *$6.95; 286 pp., illus.* SARDINIA, by Margaret Guido. *$6.95; 276 pp., illus.* CELTIC BRITAIN, by Nora K. Chadwick. *$6.95; 238 pp., illus.* THE IBERIANS, by Antonio Arribas. *$6.95; 274 pp., illus.* All from *Frederick A. Praeger.*

THERE is a reassuringly irrational maxim that says the whole is often greater than the sum of the parts. This seems to apply to the Praeger series of "Ancient Peoples and Places" and its three dozen volumes of an ever growing portrait and landscape gallery of antiquity. The occasional lapses from excellence in the series seem not to matter so much in a collection that bids fair to stand as the most comprehensive and substantial popular work of its kind on prehistory and archeology. The master plan and its essentially effective implementation redound to the credit of the general editor, Dr. Glyn Daniel. Indeed, it is a marvel that he continues to find qualified authors who are also able (or at least willing to be coaxed into the attempt) to depict their subjects in broad and, hopefully, telling strokes on small canvas. That it should not work equally well in every case, as we shall see, is understandable, but the books do hang together well and even complement each other effectively.

In this new batch of four books, the laurels go to Marija Gimbutas for *The Balts.* It is the first and, in fact, the only comprehensive book on the subject in English, and it covers an enormous time span—from prehistory to the thirteenth century A.D. It is a brilliant synthesis of history, linguistics, literature, archeology, and art, unfolding a world virtually unknown to most of us who cannot read the Slavic, Baltic, or Scandinavian languages. The author writes with authority and evocative familiarity of the land, the peoples, their history and their works. Her gifted style makes the reading a pleasure that often is exciting because of her contagious enthusiasm. A vital picture results, warm and alive with song and art. Richly anecdotal and carrying lightly its burden of scholarly documentation, the book finds comfortable space for relevant embellishment; with such asides as the Balt's love of horses, or of fine furs (an eleventh-century text is quoted to tell of their longing after a marten skin robe "as much as for supreme happiness"). Everywhere in this Baltic landscape glows the radiant solar amber—the northern gold. Among the delightful revelations in the book, we find that those very Danes who terrified the rest of Europe were wont to pray: "O mighty God, protect us against the Curonians [the Baltic 'Vikings']."

Margaret Guido's *Sardinia* scores another success for the series. Here the author surveys an island culture that was as compact and monolithic as that of the Balts was fluid and dynamic. The effectiveness of this book lies in its clarity, its good sense of order and proportion, and its unpretentious command of the subject. It covers the range of Sardinian archeology from its earliest beginnings to the Roman conquest, and enables the reader to grasp and hold the picture of this megalithic culture that seemed so intent on shaping imposing tombs and bizarre towers of immense dimensions. We are given a landscape of haunted ghost towns, cemeteries, and citadels of the vanished stone wielders. Even when we can "see" the people (in the famous bronzes of personages such as chieftains, warriors, athletes, and musicians), they confront us with mysterious solemnity and ritualistic silence.

Nora Chadwick, author of *Celtic Britain,* may have undertaken a more difficult task than the others or, perhaps, a more intricate approach. She offers us a close look, under powerful magnification, at a concentrated historical area of Britain between the end of Roman domination in the fifth, to the foundation of the Saxon kingdoms in the sixth and seventh centuries. Details and information are employed with excellent scholarly craft and, unique among these four books, the author develops and argues a distinct thesis: that this was a period of freedom in which the essential character of Celtic ideals and literature took shape. But the story becomes mired in esoteric linguistics and tangled in the knotwork of philological archeology. The ritualistic atomization of intramural scholarly modes defeats the book for ordinary purposes. Those willing to work at it, however, will find more than one flash of analytical insight, such as the comment that Welsh poetry was a "strange blend of metrical rigidity and emotional tension."

*Celtic Britain* will remain a valuable book from which students and scholars will receive profit in return for labor. The same can scarcely be said of *The Iberians,* by Antonio Arribas. Here the

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text never lives up to his characterization of the people as "energetic and colorful . . . with a zest for living." Instead we must drag our way through a tedious and not very readable agglutination of indifferently differentiated, useful, and not visibly useful information—not so much condensed as tabulated in sentence form. In part, the blame lies in the very poor translation from the author's Spanish original; the English is usually awkward and often incorrect. But this does not account for the essential defect of its presentation or the doubts—too numerous to enter upon here—that must be raised on questions of history and interpretation. The author's claim of having offered "a detailed mosaic of tiny tesserae" may tell us what he intended, but what we have is more like a jumbled kaleidoscope of tiny pieces that cannot form intelligibly interesting patterns.

Considering the professed nature of the series, it seems an editorial oversight that technical glossaries are omitted, unless, of course, it is expected that everyone will know, for example, what "a crown of feathers forming a *polos* and a *stephane* without *kestos*" looks like. Nor does it seem extravagant to expect that all authors should provide full, accurate, and reasonably uniform information on the objects, monuments, and places illustrated in each volume. The editor might also have helped with some of his authors' bibliographies. Chadwick's is exceptionally good, yet when I read a note reference to "F.A.B.W.I.," and checked against the key to periodicals, it was not there, so I may be forever in the dark as to the full name of that publication. This would be a niggling criticism if the instance were unique. The other bibliographies are far, far worse—which would be less irritating in a less valuable series.

*Dr. Bober, Professor of Fine Arts at New York University Institute of Fine Arts, often reviews books on aspects of the history of art for this magazine.*

---

DISCOVERY, by Vilhjalmur Stefansson. *McGraw-Hill Book Co., $7.50; 411 pp., illus.*

To be a polar explorer in the grand old days required a singleness of purpose and a degree of self-confidence that would find scant encouragement in the enormous governmental–scientific establishments that explore the frontiers of knowledge today. With the death of Vilhjalmur Stefansson in 1962, the old-time expedition leader became extinct. This autobiography is, therefore, a valuable contribution to the understanding of this historic group.

Stefansson discovered the last unknown lands of Arctic North America in 1915 and spent the rest of his long life popularizing the Arctic. He was an early advocate of transpolar flight and of submarine navigation under the ice. His unbounded enthusiasm for the North and for the Eskimo diet and way of life led him into the errors of an overzealous press agent, but he exaggerated less than those who thought of the North as a lifeless land of perpetual ice and snow. His greatest contribution was his conviction that the Arctic was a friendly environment where man could survive and be healthy and happy. He inspired generations of students, many of whom have devoted their lives to work in the polar regions.

There is little information about polar studies in this autobiography (Stefansson described his experiences in earlier books) but there is much about the author's troubles in Washington and Ottawa, which he clearly found less friendly than the Arctic. He is probably right when he says that "In the 1920's a sort of infighting through character assassination was practiced by those who engaged in the extremely competitive vocation of polar exploration. . . .

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Amundsen was not alone in attacking me. Others, instead of ridiculing me in public, used the expedient of trying to keep me out of socially desirable clubs." Here is a man whose happiest years were spent in the igloos of the Copper Eskimo, galled because he could not get into "socially desirable clubs" in New York.

There is no indication that Stefansson ever revised any of his ideas in the light of other people's experience or that he recognized the drastic political and economic changes that took place in the world after 1915. He consequently came to feel that his contributions were unappreciated and his advice unheeded.

In the book Stefansson tells how, in 1912, a dockside reporter "expanded" some remarks of his into a tale that he had discovered a tribe of blond Eskimos, descendants of the Vikings. Not unnaturally the story brought down a storm of criticism on Stefansson's head, but he was gratified to find when he reached New York that his sponsors, The American Museum of Natural History, had not taken the tale seriously. Nevertheless, the story plagued him for years, and he was never able to live it down, although he died at 83. The final irony is a posthumous one: the dust jacket of this book lists, among Stefansson's achievements, the discovery of "the famed tribe of blond Eskimos . . . on Victoria Island."

In sum, this is a valuable book for anyone interested in the history of exploration, and some of the most instructive reading in it is between the lines.

David Linton
*Polar Photographer-Writer*

THE AZTECS, THE HISTORY OF THE INDIES OF NEW SPAIN, by Fray Diego Durán, with translation and notes by Doris Heyden and Fernando Horcasitas. *The Orion Press, $12.50; 381 pp., illus.*

DURÁN'S *History* is one of the more important of the sixteenth-century chronicles that record the culture and history of the Aztecs of Mexico in pre-Spanish times. Our knowledge of the Aztecs is obtained from original sources of this kind, so the new translation should interest many persons who have not been able to read it in Spanish.

Durán was chosen for translation because his chronicle, more than any other, is a complete, sequential history of the Aztecs. It begins with tales of Aztec origins in the mythical seven caves of Aztlan, follows with their migrations, the history of the reign and accomplishments of each of their kings, and their eventual destruction by the Spanish invaders in 1521. Durán was relatively sympathetic to the Aztecs, for he came to Mexico as a child and grew up in Texcoco where he associated with persons who lived there before the Spaniards arrived; he also learned Nahuatl,

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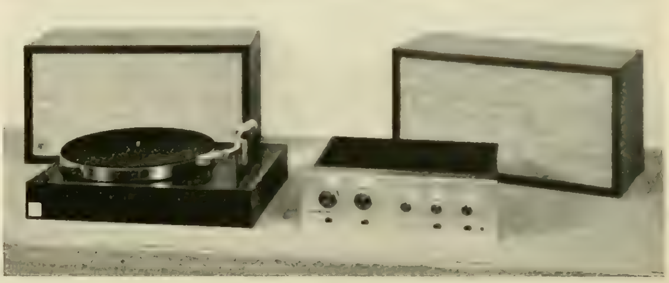

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*Also available at a slightly higher price with preamp and power amplifier separate.

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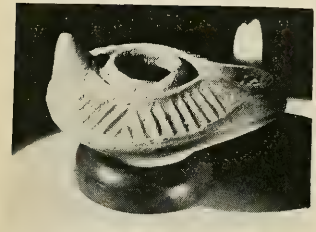

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the language of the Aztecs. In his account he often displays his Spanish inheritance by inveighing against the cruelties of human sacrifice. At the same time, he notes in some revealing statements that certain cruel actions of the Aztecs against subject people were nearly as bad as those the Spaniards might have perpetrated!

This is not a scholar's translation of Durán. The paragraphing and spelling have been altered and many repetitious passages have been omitted to make it a most readable text. Portions of the original that deal with ceremonial rites and the calendar have also been omitted.

The excellent introduction and a section of very complete notes at the end of the book clarify difficult or questionable portions of the text and are most valuable. Pertinent pages from several of the pictorial codices and a few of the drawings from the atlas that accompanied Durán's text are scattered throughout this attractive book.

Despite the alterations and omissions, the flavor of the original chronicle is maintained. By reading the remarkable story of the rise and fall of the Aztec nation, an insight may be gained into the problems faced by the historian and the anthropologist in attempting to understand a strange and quickly extinguished civilization.

GORDON F. EKHOLM
*The American Museum*

SHARKS AND SURVIVAL, edited by P. W. Gilbert. *D. C. Heath & Co., $9.90; 578 pp., illus.*

SCIENTISTS, swimmers, skin and scuba divers, and yachtsmen will find *Sharks and Survival* a must—a modern and reliable source of information about shark attacks and shark behavior.

The book resulted from a conference held in New Orleans in 1958 on "Basic Research Approaches to the Development of Shark Repellents." The participants emphasized the meagerness of biological data on sharks. One outcome of the conference was a recognition of the urgent need to expand fundamental research on sharks in order to understand and eventually to solve the problem of shark attack.

This book is a compendium of twenty-two chapters individually prepared by many of the conference participants. Its pages are replete with authentic records of the how and where of attacks, descriptions of potentially dangerous sharks, clearly dangerous sharks, and the effectiveness of present shark repellents. For those who want to explore the biological capacities of sharks, there are excellent comprehensive surveys of available data on the brain and spinal cord and on the visual, olfactory, and auditory systems. The anatomy of the systems and experi-

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ments on their functions are included and evaluated.

Other authors contribute their personal observations of, and experiments with, shark behavior, both in the open sea and under laboratory conditions—which, in the case of large sharks, are enormous pens set on the edge of the sea. The chapters are well documented with reference material, and the illustrations are abundant and clear.

EVELYN SHAW
*The American Museum*

BIRD MIGRATION, by Donald R. Griffin. *The Natural History Press, $4.50; 180 pp., illus.*

THIS little volume has all the ingredients that characterize a successful book: a fascinating subject of timely interest and popular appeal and a text that is authoritative, yet engagingly written and easily understood. It can be read in one or two sittings, although I found myself returning to certain sections to savor details of experimentation by the author and his colleagues.

Dr. Griffin gives some consideration to the general aspects of migratory behavior, including its biological advantages, its energetics, and its extent in birds and other animals. There are also brief discussions of the role played by birdbanding and by radar. But over two-thirds of the book consists of the author's penetrating analysis of the experimental studies of homing and navigation in birds—in which he rejects some theories, cautions against unwarranted interpretation of certain experiments, clarifies the problems still unsolved, and suggests possible avenues for further investigation. In addition to being a well-executed summary of progress in this fascinating but complicated area of research, Dr. Griffin's account also reveals something of the ways of those who are engaged in scientific labors, and of the personal phases of scientific discovery.

WESLEY E. LANYON
*The American Museum*

HUNGRY NATIONS, by William and Paul Paddock. *Little, Brown and Co., $6.50; 344 pp.*

FIDEL CASTRO is not a notably sympathetic character, yet a few months ago he issued a ukase that must have evoked responsive chuckles among those who have worked in "underdeveloped" countries around the globe: "I want," he said, "no more asphalt agronomists [*agrônomos asfaltados*]," vividly conjuring up an image of the foreign graduate of a college in the United States who returns to his native land and a white-collar job—and never soils his boots.

The two authors of *Hungry Nations* are not *asfaltados*. William Paddock, presently with the National Academy of Sciences, is a plant pathologist with wide experience, especially in the tropics. His brother, Paul, is a retired, rare species of foreign service officer who obviously wandered far and often from the amenities of the cocktail circuit. Between them they have produced a highly informed, well-documented book that is one of the best, if not the best, yet written on the subject of foreign aid.

They are linguists who have taken the trouble to get to know the people of the underdeveloped countries. They also (writing as a joint "I") know a great deal about climate, soils, grasslands, forests, hydrologic regimes, and the difficult topographies that divide nations and continents, and write about them in a readable, journalistic style.

The over-all thesis of *Hungry Nations* is summed up in this statement: "A country is poor and hungry for the same reasons that a poor man is hungry. The poor man is hungry because he has no capital in the bank and a poor nation is hungry because it has no resources in the ground. . . . In most hungry nations of the world the only resource that can be developed economically is agriculture." The authors have no illusions as to ease of agricultural development; they see it as a slow process—now often politically shortchanged—based on research that must be done locally. This is not a new conclusion, but it represents a minority view that has been disregarded for years. They roundly debunk the Peace Corps ballyhoo and even have the courage to point out what a liability public health programs may be!

The Paddocks recognize the dangers inherent in rapid population growth, but seem not to give sufficient urgency to a frontal attack on the problem. Perhaps events have been moving so swiftly they do not know of the effectiveness and simplicity of some of the new contraceptives. They note—but only in passing—that conservation needs are growing at the same exponential rate as population.

There are a few small inaccuracies: the authors state that corn "is no longer in deficit supply" in Mexico, whereas last winter the Mexican government was negotiating for some of our surplus. The *Servício*, a bilateral program between the United States and various Latin American nations, was one of foreign aid's most useful devices (strangely scuttled by the Alliance for Progress), but it was not originated in "the late '40's." It was founded during the war, when Nelson Rockefeller was Co-ordinator of Inter-American Affairs. There are some inconsistencies that competent editing should have resolved. But these blemishes are relatively minor.

The Paddocks' analysis of the self-defeating structure of our foreign aid programs is acute. And they advance

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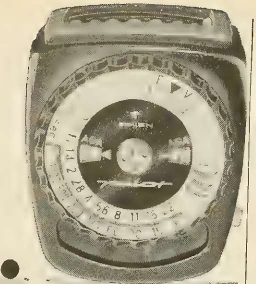

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suggestions for reorganizing foreign aid that are constructive and promising. Their most telling remark is a quote given to a journalist who was writing on the aid program: "We are asked to use five-year plans to cope with twenty-year problems using two-year personnel and one-year money."

This is a book no responsible American citizen should miss.

WILLIAM VOGT
*Ecologist and Conservationist*

THE WORLD OF BIRDS, by James Fisher and Roger Tory Peterson. *Doubleday and Co., $22.95; 288 pp., illus.*

BIRD books have evolved from regional to state or country, to continent, to worldwide in scope; and, of course, the numbers of illustrations have increased accordingly. At the same time, there has been an accompanying, and more rapid, evolution of the birders' sublanguage. This symbol language began in a simple way—jotting down "20 GBH" (twenty Great Blue Herons) on a tally sheet or giving a locale an "RBH" (rare birds/hour seen) Hooper-rating. *The World of Birds* takes off in various directions beyond such a historical past. According to the authors, this opus on "our beloved science" is concerned with the "gorgeous material" comprising the "avifauna of our planet," and also with the "tools and tasks of international birdwatching."

This is no conventional "birds of the world," and innovations abound. One notes in the language area, for example, that "total population of a species" has evolved to "*world* population"—even though a species may breed at only 29 places in the North Atlantic or total occurrence be limited to a couple of California counties. At the graphics level, there are silhouettes of various birds whose only known record may consist of a few bones millions of years old. This is a considerable book. It is one-stop ornithological shopping.

It touches on about everything of possible interest, birdwise, presented at just above mass-market level: variations of all sorts, evolution, habits, distribution, migration, behavior, flyways, nest-records projects, bird feeders, banding, bird blinds, sound recording, the ornithologist's bookshelf, the equipment of the affluent bird photographer, etc. In 1935, Herbert Friedmann wrote: "On the whole, most birds, at least when not breeding, prefer not to be alone." Some sort of parallel is encouraged among birders in the section of this book on togetherness—including photos of various "Old Club" neckwear, with a high population-density of Puffins, Terns, Avocets, and Crested Tits. Distribution of each family of birds (extinct, living) is mapped and statistics are appended.

There is a survey of the relation of bird and man: fowling, falconry, domestica tion, guano, cockfighting, pest specie bird-borne diseases, conservation, an more. A list of birds in danger of becom ing extinct, another of those that quitte our planet after A.D. 1600, an elaborat index, and even special color work fo the dust jacket are also included.

The abundant color work is tops (M Peterson's style is freer than in hi familiar guides, his values are closel rendered, and there is good handling o sheen), well reproduced but apparentl at some sacrifice in the quality of repro duction of the black-and-white photos.

When at your bookseller, pass by th economically priced field guides (you al ready have these, well worn) and th middle-priced "think pieces" (buyer re sistance is high here). Go directly t the coffee table items in the $20-plus bracket (resistance wanes; a status symbol is a "must"). Join the queue. You are about to acquire instant ornithology in a king-size package.

RALPH S. PALMER
*University of the State of New York*

The following books are listed for special interest readers.

WILD FLOWERS IN SOUTH CAROLINA, by Wade T. Batson. University of South Carolina Press, $5.00; 146 pp., illus.

TREES, SHRUBS, AND WOODY VINES OF GREAT SMOKY MOUNTAINS NATIONAL PARK, by Arthur Stupka. The University of Tennessee Press, $2.75; 186 pp., illus.

A GUIDEBOOK TO THE SAN BERNARDINO MOUNTAINS OF CALIFORNIA, by Russ Leadabrand. The Ward Richie Press, $1.50; 118 pp., illus.

DICTIONARY OF HERPETOLOGY, by James A. Peters. Hafner Publishing Co., $11.50; 392 pp., illus.

A NEW DICTIONARY OF BIRDS, edited by Sir A. Landsborough Thomson. McGraw-Hill Book Co., $17.50; 928 pp., illus.

FISHES OF THE WESTERN NORTH ATLANTIC, compiled and published by the Sears Foundation for Marine Research, Yale University. $27.50; 599 pp., illus.

THE LIVES OF DESERT ANIMALS IN JOSHUA TREE NATIONAL MONUMENT, by Alden H. Miller and Robert C. Stebbins. University of California Press, $10.00; 452 pp., illus.

DUCKS, GEESE, AND SWANS, by Bertel Bruun and Lief Rydeng; THE CORAL REEF, by Alfred Butterfield and Jerry Greenberg; THE INSECT WORLD, by Walter Linsenmaier; RARE AND EXOTIC BIRDS, by Robert Cushman Murphy and Arthur Singer. All from the Odyssey Press, 95¢; 45 pp., illus.

**1.** THE YEAR OF THE GORILLA. *George B. Schaller.* Thrilling account of 2-year expedition into the realm of Africa's mountain gorilla. "A superb book" – *N. Y. Times. List Price $5.95.*

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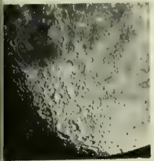

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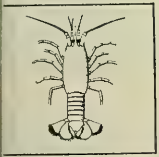

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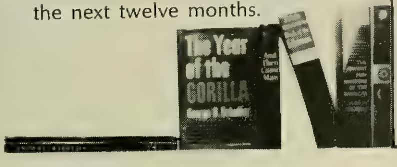

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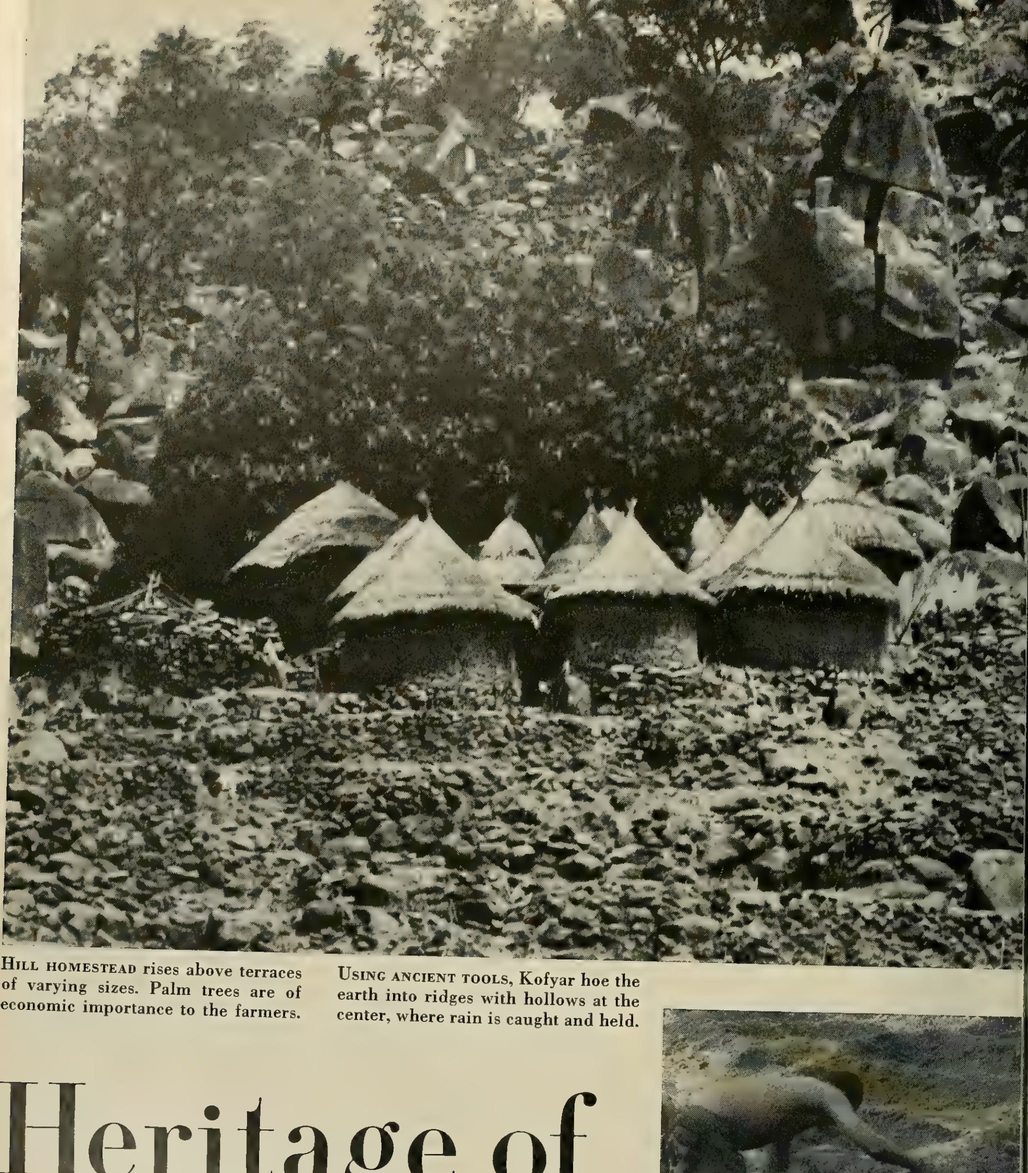


Hill homestead rises above terraces of varying sizes. Palm trees are of economic importance to the farmers.

Using ancient tools, Kofyar hoe the earth into ridges with hollows at the center, where rain is caught and held.

# Heritage of Survival

## Kofyar terraces preserve soil and water

By Robert M. Netting

PEOPLE who live in mountainous country tend to be hardy and independent. Their cultures are frequently the isolated and conservative backwaters of more fruitful lowland civilizations. To the outsider, hill folk often seem clannish and suspicious, preferring with unaccountable pride their impoverished fields to greener and more accessible pastures elsewhere. On the slopes of the Jos Plateau in the Northern Province of Nigeria, there are peoples with a similar heritage of resistance to conquest and a rugged insistence on cultural individuality. But their tiny territories, instead of being depressed areas, support some of the most intensive and ingenious agriculture south of the Sahara. These people have been condescendingly called "hill pagans" by the Moslem Hausa-Fulani, the dominant ethnic group of the northern region, and by the former British administration. But in fact, these groups display creativity of a high order in their adaptation to a restrictive environment.

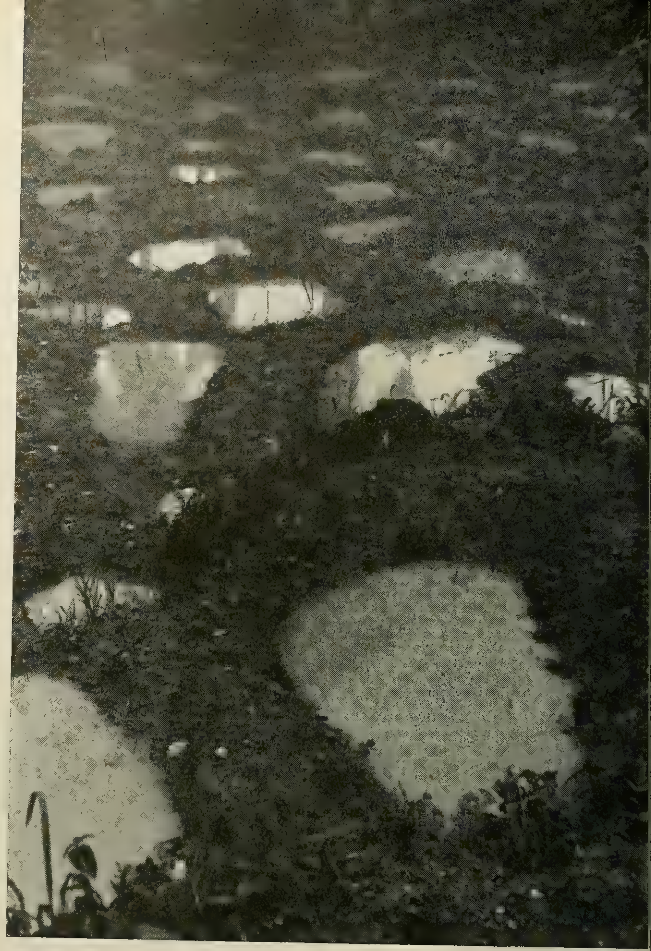
THE Jos Plateau rises precipitously from the plain and contrasts sharply with the surrounding savanna country and the monotonous palm bush area farther to the south. An escarpment rises 1,500 to 2,000 feet along the southern edge of the boot-shaped plateau, and its slopes are punctuated with volcanic cones and craters, swift, clear streams, and scattered patches of deep-green oil palms. At the top, cool, rolling grasslands remind American travelers of the Great Plains in the United States.

It was the unique geography of the area that led Europeans to the plateau near the turn of the century, first to mine the alluvial tin, which exists there in important quantities, and later to take advantage of the pleasant climate for vacations from administrative and business duties in other parts of Nigeria. The special qualities of the terrain and certain of the natural resources had long before been perceived and used by peoples who had settled the plateau and developed ways of life that are in some respects unique in tropical Africa. Within seventy-five miles of the great mining dredges and the lively commercial city of Jos are some thirty population groupings (many of them still poorly defined), speaking languages of two major linguistic families and maintaining a striking range of costume, religious practice, technology, and social organization.

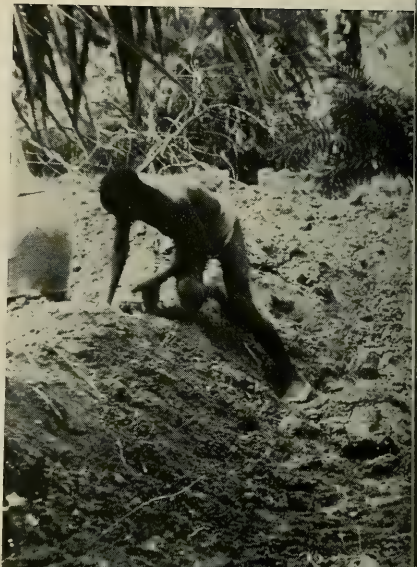
Especially in the broken terrain on the edge of the plateau, tribal areas and communities are small and varied. Long ridges stretch south like buttresses from the main body of the plateau, and each has its own cultural group. Just as Appalachian mountaineers in isolated coves developed local differences in song and crafts, the plateau hill folk, over a much longer period, have remained in self-sufficient pockets and have gradually diverged from each other. Preserved from conquest and accompanying cultural change by their rocky uplands, and kept apart from each other by natural barriers and mutual hostility, the hill dwellers form enclaves of from 3,500 to 80,000. Of these, the largest and best-known groups are the Birom, Angas, and Sura. They were never incorporated by the Hausa-Fulani kingdoms, as they expanded into areas north, east, and west of the plateau during the nineteenth century. The rocky hills also shielded their inhabitants from mounted Moslem slave raiders who systematically harried other pagan tribes.

My own anthropological field experience in this area was mostly with a group that may be called, for the sake of convenience, the Kofyar. For the most part, they acknowledge no such general title themselves, having no traditional political unit larger than a village or village area (such as Mirriam, Dimmuk, Kwong, Kwalla, and Doka), and no paramount chief or tribal organization. They do have strong similarities in dialect and custom, however, and share a myth of origin from an ancestor, Kofyar. This man, it is said, survived a primordial cataclysm by taking shelter in a cave with his sister. Offspring of these two repopulated the area and migrated from the original hill village, which is still known as Kofyar (or Koffiyer). For governmental and judicial purposes, several of the constituent village areas have been officially united as the Koffiyer Federation and the rest have been invited to join. Yet to this day, individuals will identify themselves, not as Kofyar, but only as natives of a particular village.

More than 50,000 of these people live in a geographically demarcated territory of about 200 square miles—a



**Crops** are planted on the ridges between the basins, where they will not flood, and basins hold rain even when it falls torrentially.



**Yams** and sweet potatoes are among the root crops to be planted on the ridges, here being hoed. Women bring ashes as a fertilizer.

Corn is planted at start of rains, which last from April throughout September, and may total five feet. The basins permit slow seepage.

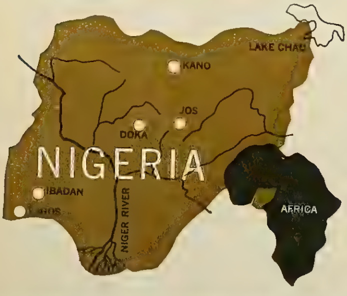
Women transplant millet on the basin-listing ridges. Kofyar farm on subsistence level, but their methods keep people famine-free.

line of hills and an immediately adjacent band of plains at the foot of the escarpment some 70 miles southeast of Jos. Although groups such as the Goemai or Ankwe and the Sura are within an hour's walk of the nearest Kofyar villages, and interchange is frequent, the Kofyar language, dress, house type, and agricultural practices differ markedly from those of people in neighboring communities.

The local development of Kofyar farming techniques are particularly interesting. With the publication of recent books on the shifting cultivation of the Azande in the Congo, the alluvial gardens of the Rhodesian Tonga, and the Sonjo method of irrigation in Tanganyika, we are just beginning to realize the skill and ingenuity with which Africans have adapted indigenous agriculture to various environments. The most widespread method of growing crops south of the Sahara is shifting, or swidden, agriculture, in which a field is farmed until its yields decline. It is then allowed to remain fallow until fertility has been naturally restored. This requires a considerable land area per person, however, and may lead to overcultivation in the event of rapid population increase. In striking contrast to this, the Kofyar practice intensive agriculture, supporting a dense population on permanent farms that maintain heavy production from very limited areas.

When I first entered the Kofyar area in November of 1960, it was almost impossible to see the thatched huts of individual family homesteads because of the thick growth of grain sorghum (*Sorghum vulgare*) that surrounded them. I later discovered that a crop of early maturing millet (*Pennisetum typhoideum*) had already been harvested from the fields and that cowpeas, okra, and pumpkins were interplanted with the sorghum. Homesteads were not clustered in nucleated villages, but were dispersed, each family living in the center of its field. The average size of a field was just over an acre. These intensively cultivated plots furnish the bulk of their owners' food year after year for generations. The Kofyar are almost without exception subsistence farmers, yet they maintain a famine-free population approaching 1,200 persons per square mile in some areas. They do this without irrigation or domestic animal power, and with tools no more

**In plains villages**, ridges are built at end of wet season to retain rains.



complex than the iron-bladed Sudanic hoe, the ax, and the sickle.

The Kofyar environment provides certain advantages and also imposes severe limitations. Rain falls in quantity during six months of the year, from April through September, when it totals forty to sixty inches. Kofyar country includes part of the escarpment that intercepts rain-bearing winds from the south, thus insuring a more dependable supply of moisture than the high plateau lands farther north. The rain water is absolutely necessary for agriculture, of course, but it can also be a dangerous force, swiftly eroding exposed hillsides and turning low places into swamps. Hill soils may not be deep, but they are well supplied with minerals from rock decomposition. Thus, although fields are initially productive, two or three years of repeated grain crops are enough to sap much of their vigor.

The most conspicuous achievement of the Kofyar is their successful con-

**Over head** of worker is an "increase arch" that insures successful harvest.

**Intense** cultivation includes early maturing millet crops, *right*, and corn.

servation of water and soil. Wherever practical, the hillsides are terraced with rough stone walls one to six feet high, which anchor the level patches of soil. Terraces are higher on the intensive farms around the homesteads, where it is an advantage to have wider plane surfaces and deeper soils, but even bush fields outside the village, used only on a shifting basis for small crops such as peanuts, are terraced.

Although some of their neighbors also terrace on a smaller scale, the Kofyar are unique in performing a process called basin listing. They hoe the earth into rectangular ridges and leave a hollowed-out depression in the middle. They plant their crops on the ridges, where they will not be inundated, and the basins retain the rain water, even when it falls in a violent deluge. The system has the twin benefits of holding rain water so that it sinks gradually into the soil for use by the growing plants, and of preventing destruction caused by rapid runoff and erosion. Thus steep, treeless hillsides are preserved as a productive resource. The Kofyar recognize that leaching and washing of topsoil lead rapidly to infertility, and when I asked them why a particular field was exhausted, their reply was frequently *am mang*, "water carried it off." Professional agricultural engineers have told me that Kofyar methods of soil conservation could not be improved.

The obvious investment of labor in terracing is impressive. Farmers keep up their old fields, but there is little new construction of terraces today. In the past, building was done, not by organized groups, but by individuals who raised single walls and then pulled earth down to form a level bench.

ONE old man who had literally carved his farm from the hill often berated his children for their laziness and compared his achievement to the puny efforts of the modern generation. Terraces are still mended by volunteer groups who are rewarded with beer by the field owner. Almost all farmers continue to follow the basin-listing pattern, and even on the plains the waffle-like ridges are erected toward the end of the wet season to retain the last rains. The Kofyar are equally adept at dealing with waterlogged areas. There they make rows of high mounds at right angles to the slope and separated by channels to carry off the excess moisture. Every technique used is adjusted to the terrain. A single field may be terraced and basin-listed on the steeper slopes, basin-listed on relatively level stretches, and ditched on the poorly drained bottom areas.

**WORKERS are rewarded with beer that is made from millet after the harvest is in. Traditionally, these people are aware of the need for crop rotation.**

In order to support continuous intensive agriculture, the Kofyar must both conserve soil and water and restore some of the nutrients that their crops take from the soil. Fertilizing the ground by systematic application of manure is practiced very little in traditional African systems of agriculture. The Kofyar meet the problem by careful accumulation and application of organic material. Each household has a round stone-walled *bit*, or corral, ten to fifteen feet in diameter, situated near the entrance to the homestead. All the goats belonging to family members are staked there throughout the growing season. Women and children fetch water, fresh green grass, and leafy branches for them daily. Substantial quantities of uneaten fodder mixed with goat dung accumulate in the enclosure and are removed and distributed about the field by a group of co-operating neighbors just before the rains come. They also clean out the huts where the goats are penned at night. Successive cultivations of the maturing crop work the compost into the soil. The Kofyar also take advantage of the recent arrival in the area of Fulani nomads by paying them to herd their cattle on bush fields where the fertility is low.

While the homestead farm (*mar koepang*) is heavily fertilized to make annual crops of large grains possible, the Kofyar also cultivate extensive areas beyond the periphery of the village. They farm these bush fields (*mar goon*) on a shifting basis to produce subsidiary foods, and although they do not spread compost on bush lands, they use certain other fertilizing agents selectively. For instance, every bit of wood ash is saved from household cooking fires and stored in specially built huts. Women carry the ash to the field in baskets and apply a handful at a time to individual plants of peanut and sweet potato. Secondary growth and weeds are also piled and burned in fields to furnish ash beds.

THE Kofyar follow still another practice in the case of *acha* (*Digitaria exilis*), a grass with tiny seeds that may have been domesticated in the western Sudan. All shrubs and grasses growing in a field are uprooted and piled in rows to be covered with small ridges of earth. The *acha* is then sown broadcast.

In addition to green manuring and the use of ash in the bush fields, the

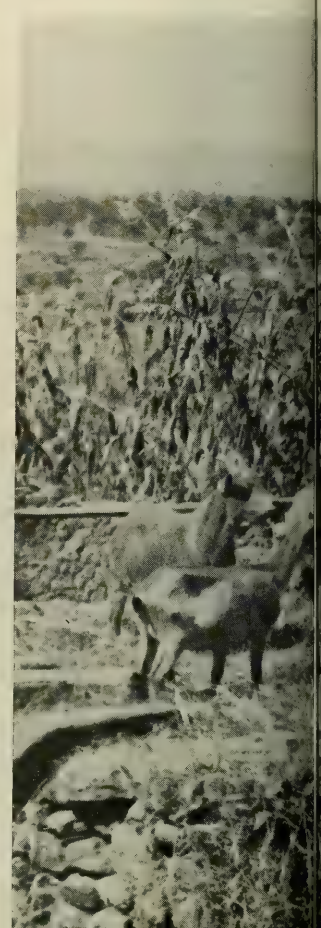
Kofyar practice a regular crop rotation. They recognize that *acha,* alternated with peanuts, keeps the ground in good condition longer. Bush fields can be kept in production for six to nine years before fallowing. With a single crop, the soil, they say, becomes quickly worn out and white (*bes piya*). They also take pains to adapt their planting to particular microenvironments, growing coco yams as a staple in damp sections of the village, and sorghum in drier areas that have more direct sunlight. Use of early and late millets is also closely related to rainfall. Different varieties of sorghum are used in red volcanic soil and in the more common brown earth.

QUESTIONS as to the origin of Kofyar agricultural practices are not easily answered. Although many African farming groups spread household refuse on small garden patches, few approach the systematic manuring of the Kofyar people. The Chokfem branch of the Sura, who live in an environment almost identical with that of the hill Kofyar and who speak a closely related language, merely stake their goats out individually along paths and in uncultivated tracts. Terracing, often of a rudimentary sort, occurs at various places on the Jos Plateau and among Chadic-speaking groups in the hills of Adamawa and Sardauna provinces. In tools and crop varieties, the Kofyar resemble the pagan peoples found throughout the western Sudan, but the manuring, basin listing, and crop rotation patterns appear to be indigenous. The practices are not traceable to colonial influence, since Europeans did not enter the area until 1909, and effective control of the hill villages came only after the military operations in 1930. In the absence of historical records and archeological evidence, we may surmise that the Kofyar independently developed many of the features of their agricultural system.

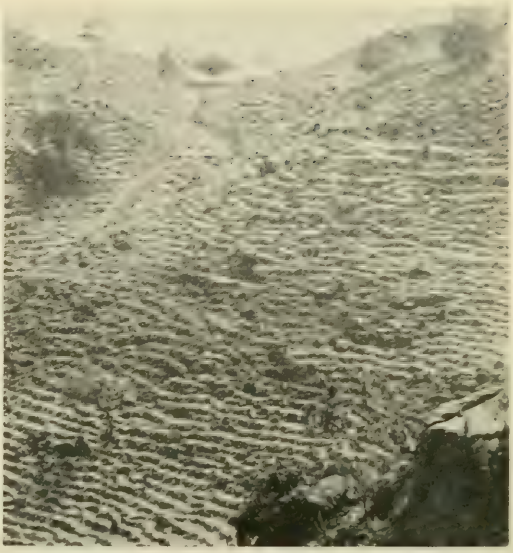
Kofyar agriculture is by no means static and resistant to change. New varieties of coco yams and European-introduced strains of peanuts are gaining wide acceptance. Marshy lands at the base of the escarpment have been diked and put into wet rice production within the last twenty years. Just before I left the area, a number of villagers approached me to request seeds of the tomatoes in my garden.

The most important development, however, has been the rapid expansion of Kofyar farming. The cessation of warfare and slave raiding, combined with the opening of markets and roads to urban centers, made growing of surplus crops both practical and profitable. The Kofyar were able to leave the protection of their hills and break vacant land to the south. Migration began about 1930 and served originally to reduce population pressure in some villages that lacked sufficient land. Within the last fifteen years, an increasing proportion of farmers have concentrated on cash crops. The new pattern consists in taking up unoccupied land around Namu or Kurgwi, some thirty miles away, while keeping the traditional homesteads in production. Men and their families commute between the two areas. This is possible because crops planted on the pioneer farms mature at different times from those at home. During the normally slack period of the dry season, many Kofyar make "heaps" for the profitable yams that thrive on the lowlands. These mounds, or hillocks of earth, $1\frac{1}{2}$ to 2 feet high and roughly conical, surround the growing tubers. Sorghum, millet, and cowpeas are also grown for market by using only the techniques of shifting agriculture. The new land must often be cleared of trees, but it is fertile enough to support several years of cultivation before fallowing. It is level and easily worked, so that methods of ridging, terracing, or manuring are not needed. The Kofyar have miles of idle land waiting for use, and as practical farmers they see no reason for the increased labor and slower profits involved in more stable exploitation. Their cash cropping has been established voluntarily without official encouragement. They are doing what they know best in a way that allows continuity of family and village life, plus access to the modern money economy with its concomitants of cloth, bicycles, kerosene lanterns, and school fees.

WHEN I asked them if they would leave the hills permanently, the Kofyar replied that they would stay with the graves of their forefathers. A few families from those villages where land is in short supply have found it advantageous to shift residence to the lowlands. There are limits to the numbers that can be supported even by Kofyar agriculture, and young men who would normally take up a vacant homestead have no place to go. With continued population expansion, this alternative may be increasingly chosen, but at present the majority of migrants maintain two farms, practicing intensive agriculture in the home village and shifting cash cropping on the plains. The compromise allows them to enjoy the best of both worlds. Middleman functions are being taken over by local entrepreneurs, and one of the plains chiefs has invested in a truck that goes regularly to the Jos market. The Kofyar response to the opportunities of a modern cash economy is proving as effective as their initial adaptation to the physical requirements of hill agriculture. By varying their techniques of exploitation, they have been able to maintain a dense, stable population while enjoying natural protection from their enemies and, more recently, realizing the benefits of market relations in the larger Nigerian business society.



**Grain sorghum**, towering over load carrier, at left, indicates, by its height, the fertility of the soil.



**Hill terraces**, which allow high food production from limited areas, demonstrate the ingenuity of Kofyars.

**Goat dung** is important to hill people for fertilizing crops. Herds are corralled near homestead entrance.

# Day Length and Food

## Photoperiods cue the flying squirrel

By Illar Muul

Animals born during the spring or summer have no actual conception of the coming winter season. Instead they are genetically equipped to prepare for it through physiological adjustments that have their beginnings in neural responses to various environmental cues. Such cues may be temperature, light intensity, photoperiod (or day length), barometric pressure, lunar cycles, sun spots, or one of a host of others that are less well known. Exhaustive and thorough studies have linked many natural phenomena, such as bird migration, seasonal reproduction in birds, molting in mammals, regulation of activity cycles, fat deposition preceding hibernation, and others, to one or another of these cues.

Among the many cues listed, photoperiod and its effects have been most intensively studied, because on an annual basis and from year to year it is one of the most reliable cues. This would explain why so many animals have evolved physiological dependence on photoperiod. Other cues, such as light intensity and temperature, may vary daily, seasonally, and annually without a precise pattern. They may be affected by changes in cloud cover and other climatic factors.

The use of environmental cues not only brings physiological processes into synchrony with environmental events, but also allows the animals to anticipate change. This is especially important for processes that require some time for preparation, such as prehibernation and premigratory fat deposition. These processes must be initiated weeks or even months before hibernation or migration can begin, and are started in the favorable part of the year during which there is no direct hint of the oncoming winter season. A decreasing photoperiod in itself does not predict the rigors of winter, but those animals whose physiological

# Caches

**Control group**, *left*, was exposed to normal light and temperature outside.

**Food storage** activity in the flying squirrel is intensified in the autumn.

processes were keyed, during their evolution, to this subtle but reliable change in environment, prevail today.

Hibernation and migration are the ways in which animals can deal with winter. They avoid the problem of low temperatures by seeking a protective shelter, burrow, nest, or a more favorable climate; in hibernators, the body temperature is lowered to reduce the heat gradient between themselves and the environment and thus decrease the expenditures of living.

For those animals that remain active through the winter, a severalfold increase in the expenditure of energy is often necessary to compensate for the body heat lost to the environment. This additional energy comes from fats stored within the body or through increased food consumption. In many species, increased food demands are met by stored food supplies accumulated during periods of abundance.

Food-storing behavior, although found in a wide variety of animal groups, is most prevalent among the rodents. My interest in this behavior was sparked during a general study of the smallest of our New World squirrels—the flying squirrel, *Glaucomys volans*. Although they may store a certain amount of food all through the year—as many as twenty nuts a night per individual—this activity is greatly intensified during the autumn, coinciding with the ripening of the mast crops, at which time the animals may gather as many as three hundred nuts nightly. The main question, then, was "What makes the storing activity increase?"

In the northern states, hickory nuts and acorns are the main items found in food caches. The former, however, seem to be favored by flying squirrels. In good crop years, hickory nuts comprise more than 90 per cent of the food cache; during poor hickory years, the bulk of the stored food is acorns. This food is not only used during the winter but also through the spring and summer until the next crop ripens. In summer, the squirrels also eat other vegetable matter and insects. In winter, their diet is supplemented with dormant insects, buds, bark, and fungal growth. During the period of food caching, exploratory behavior, which results in the discovery of storable food items, is greatly increased. Nuts and acorns that have dropped to the ground are apparently found among the leaf litter by their odor. Considerable numbers are also cut from the trees.

Unlike the red squirrel, *Tamiasciurus hudsonicus,* and the chipmunk (notably *Tamias striatus*), flying squirrels make no single cache; instead they store the food in various places on the ground and in the trees. On the ground no excessive digging is done. While holding the nut with its teeth, the squirrel merely parts the leaves with its forelegs, pushes the nut between its hind legs, and, with tail erect, wedges it into place with a few blows of the snout. The nut is then covered with leaves and the squirrel goes on to find another. Much of the food is carried up into trees and stored in various cavities, cracks, unfinished woodpecker holes, and in the forks of branches. In such storage sites, the nuts are pounded firmly into place with the bared incisors. The sound of this pounding can be heard clearly during autumn nights.

SINCE the flying squirrels often aggregate during the cold months in numbers of twenty-two or more individuals in a nest, the storing effort becomes a group project, resulting in common storepiles distributed among the various places that the members frequent. The squirrels then share the stores during the winter and after the aggregations break up in the spring.

This much of the food-storing behavior can be observed in nature; answers to more specific questions had to be arrived at experimentally under controlled environmental conditions. Under natural conditions, the intensity of storing begins to increase in mid-September, reaches a peak in November, and drops back again to the basal level (fewer than twenty nuts a night per individual) by mid-January. During the peak period, an individual squirrel in captivity may store as many as 270 nuts in one night. This is a good "profit," for during this time it costs the squirrel only about seven nuts for each night's food under natural conditions; even fewer are eaten in captivity. Of course, weather, availability of food, and other factors influence the specific number stored on any one night by squirrels in their natural environment, but the general

**FLYING SQUIRRELS store nuts both in ground and in trees. In this sequence animal manipulates nut with its paws, pushes leaves apart with forelegs, and, tail erect, wedges the nut into place.**

trend is the same as in the laboratory.

Initially, my aim was to determine the environmental cue that triggers the characteristic autumn period of intensive food storing. The most obvious candidate was food availability. But when hickory nuts were offered to the squirrels during the summer, the number stored remained at the basal level of approximately twenty nuts per squirrel in a night.

Temperature and photoperiod both decrease in autumn, so that either could serve as a cue for storing. To test the effect of these two cues, I placed four experimental groups of ten animals each under various temperature and photoperiodic conditions to subject them to different combinations of the two factors. These will subsequently be referred to as the control group, and Groups I, II, and III. The animals were kept in male–female pairs, and each pair was provided with a nest box and a five-compartmented storage box. Sunflower seeds were always available for food, and vitamins were dissolved in the drinking water. Nuts were placed in a pile on the cage floor and those stored were removed from the cage and counted the next day. Initially, fifty nuts were given to each pair, but the number was increased as soon as the squirrels began to remove most of them.

The control group was kept out of doors from September through January, and exposed to normal temperatures and photoperiods; they should therefore have responded in a way parallel to that of animals in nature. This proved to be the case, but the storing performance of this group reached a peak later than is seen in nature. The explanation for this difference probably can be found in the availability of food. In nature, the storable food material is used up, while the storing drive, as reflected by the outdoor group, still persists. Under natural conditions this assures that the squirrels would react accordingly if new food supplies became available.

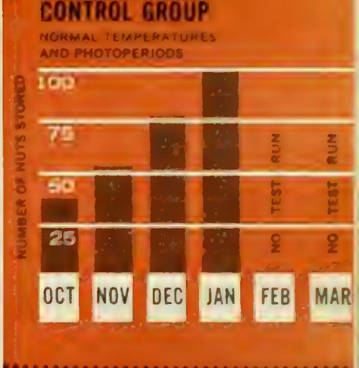
Group I was subjected to seasonal photoperiods in the laboratory from September through March, but the temperature was held constant. Thus the animals had the benefit of natural day length, but lacked the temperature cue. The performance of Group I was very similar to that of the control group, but its storage peak was higher (*graphs at right*). From these results, one can see that photoperiod is sufficient to trigger the storing response independent of seasonal temperatures.

Group II had the benefit of seasonal temperatures, but was given a long photoperiod of fifteen hours of light, which is equivalent to that of summer. Although the seasonal temperature changes evoked some increase in the intensity of storing, peaks such as were seen in the first two groups were not reached until March, when the photoperiod to which this group had been exposed was reduced by three hours. The performance of this group further demonstrated the importance of photoperiod. In March, temperatures are usually on the increase, yet a shortening in the relative day length still evoked an increase in storing. It should be noted here that according to calendar time this increase in storing took place when the performance of the other groups was decreasing.

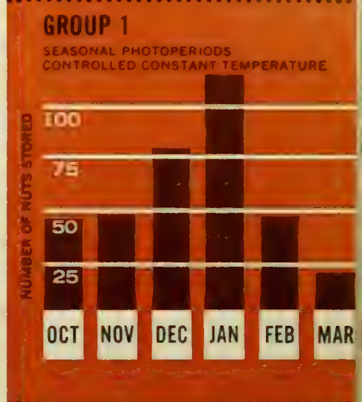
Group III was initially maintained under constant temperature and a photoperiod of fifteen hours. The storing performance during this time was the lowest of the four groups. During mid-December the photoperiod was reduced by two hours, and within a week the group performance increased to approximately the same level as that of the control group and Group I, both of which were under natural photoperiods. No further decrease was necessary to maintain the performance at this level until mid-February, at which time storing by the normal photoperiod groups was also decreasing.

DURING the second year of study, a group of squirrels was subjected to a controlled photoperiod in mid-October equivalent to that which the animals would usually encounter in the middle of November. The intensity of storing increased more rapidly than normal and reached a level equivalent to that of the middle of November under natural conditions (*graphs page 26*). This means that nightly a pair of squirrels stored about eighty more nuts than did pairs under natural photoperiod. Subsequent decreases in photoperiod brought about an even more accelerated performance. By the beginning of November the squirrels were subjected to photoperiods characteristic of late December, and began to store at their peak performance.

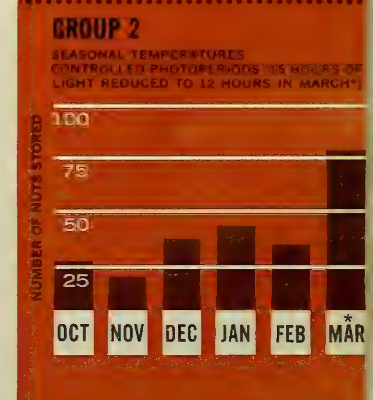
Immediately after, the photoperiod regime was changed to fifteen hours light and nine hours dark, which is equivalent to midsummer. In some in-


CONTROL GROUP

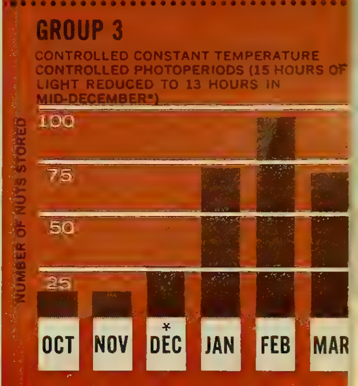
NORMAL TEMPERATURES AND PHOTOPERIODS


GROUP 1

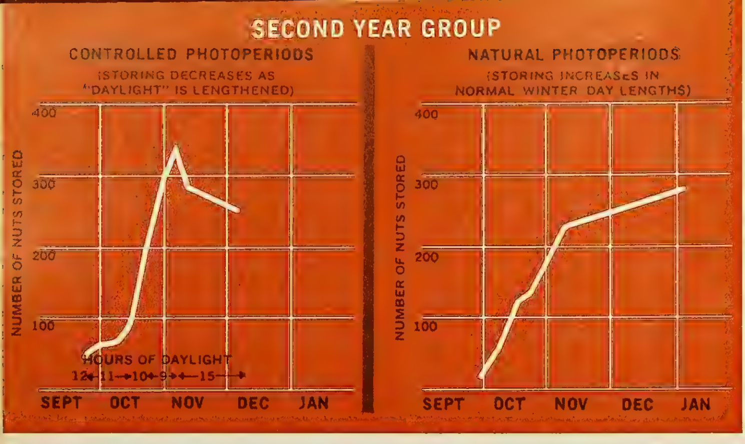
SEASONAL PHOTOPERIODS CONTROLLED CONSTANT TEMPERATURE

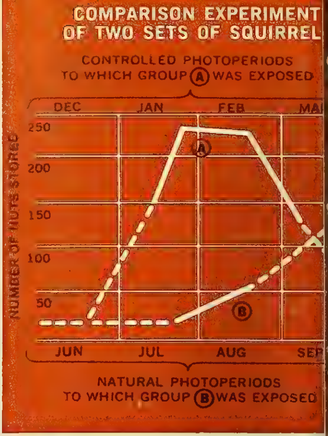

GROUP 2

SEASONAL TEMPERATURES CONTROLLED PHOTOPERIODS (15 HOURS OF LIGHT REDUCED TO 12 HOURS IN MARCH*)


GROUP 3

CONTROLLED CONSTANT TEMPERATURE CONTROLLED PHOTOPERIODS (15 HOURS OF LIGHT REDUCED TO 13 HOURS IN MID-DECEMBER*)





dividuals the storing intensity dropped down to basal levels; in others the decrease was not as marked. The general trend during the subsequent weeks was a decrease in storing, although it was still increasing in the group exposed to natural photoperiods.

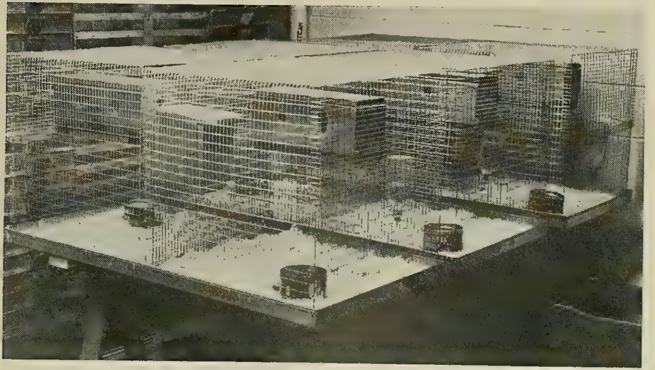
The next test was conducted with squirrels which, in the spring, had been placed under photoperiodic conditions equivalent to those of October. By controlling the room lights with an astronomical timer, day length was decreased by increments of about seven minutes a day, as would normally occur during the fall season. By the middle of July the photoperiod was equivalent to that in mid-January. A comparison of the storing performance of this experimental group and one under natural photoperiod conditions at that time (July) showed roughly a 10 to 1 difference in favor of the "January group" (*graph top right*).

Such manipulations of the light–dark cycle demonstrated further the dependence of the flying squirrel on photoperiod as a cue for storing. This dependence assures that intensive exploratory behavior is synchronized with the ripening of the mast crop, and relieves the animal from unfruitful exploratory and "searching" activity during the remainder of the year. It would be energetically wasteful to engage in this kind of activity during times when food suitable for storing is not available; it could also interfere with other activities, such as reproduction and nest building, that are necessary for the survival of the species. The delay in intensive storing activity until a specific time also prevents premature harvesting of the mast crop. Hickory nuts are nearly full-size by July, but do not ripen until fall, so visual cues would probably be ineffective.

EARLY in the experiments on food storing, I stumbled on another phenomenon that probably plays an important part in the storing process. Because I had only the help of my fifteen-year-old brother-in-law in gathering the hickory nuts that were used in the experiments (these amounted to many bushels), I tried to use some over again after the squirrels had once stored them. In each case, however, the storing performance decreased markedly. Given a choice between "new" nuts and those which had been stored previously, the new ones were taken at a ratio of about 4:1 (*graph, opposite page*). This suggested that the nuts were somehow marked during the storing process, either physically or perhaps by an odor marker from the mouth or feet.

There are modified sebaceous glands on the infolded lips of some rodents, described by Dr. W. B. Quay, and some rodents reportedly possess modified sweat glands on the soles of their feet. If such glands are present in the flying squirrel, either could serve as a source for the marker because both the forefeet and the mouth come in contact with the nut.

By washing both new and previously stored nuts with hot water and detergent, the apparent discriminatory ability was reduced, but the animals still preferred the new nuts at a ratio of about 2:1. I also washed nuts in carbon tetrachloride, rinsed them with water, and dried them. These nuts did not seem to be as attractive to the squirrels as were fresh nuts, but the animals could not distinguish between previously stored and new nuts that had been treated in this way. The marker obviously could be washed off, so it appeared at this point that an odor was involved. The marker was not washed off completely in water, but because detergents and carbon tetrachloride dissolve oils, the possi-



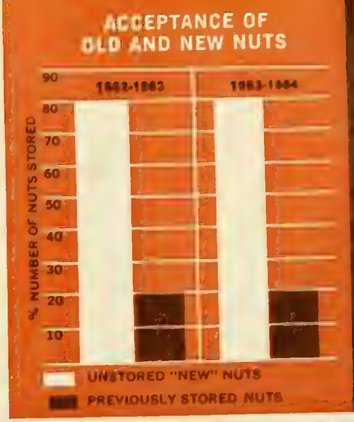
**LABORATORY** animals were subjected to artificial conditions of light and heat.

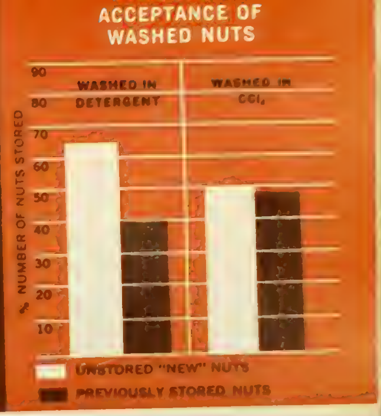
ility of some kind of oil marker arose.

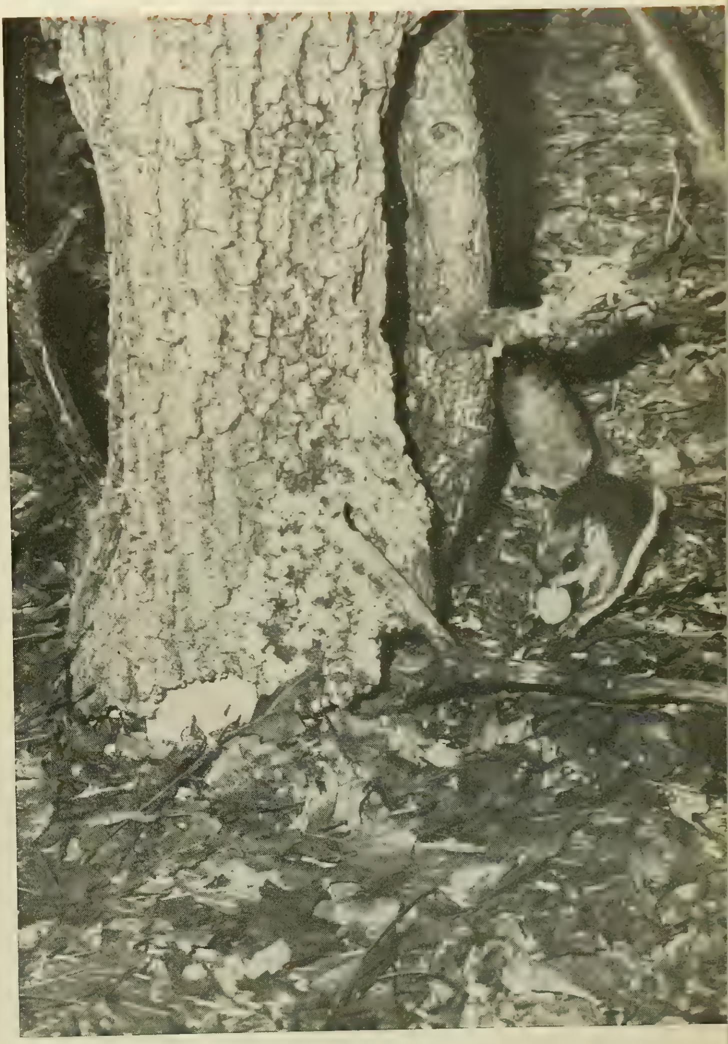
Working from this premise, it remained to be found where this substance had its origin—the lips or the eet. Some nuts were presented to the quirrels on wire trays placed on top f their cages. To touch them, the quirrels had to reach through two ayers of wire. In this way, only the eet came into contact with the nut as a squirrel grasped it and attempted o pull it into the cage. After a nut had been sufficiently handled by a squirrel, I removed and marked it. When Forty had been processed in this manner, they were presented to the squirrels with an equal number of new nuts. The response to the two types of nuts was the same—neither was preferred over the other. Although this seems to narrow down the source of the marker to some substance in the mouth, a great deal of work still must be done to isolate it.

The biological significance of the mechanism concerned here can only be surmised. Perhaps it is a way of assuring that the animals gather new nuts rather than regathering either those already stored at a previous time or those stored by other individuals. As described earlier, many of the stored food items are in plain view in the trees the animals frequent. A squirrel that is disposed to gather nuts as a result of photoperiodic changes could do so most easily by picking up those that have already been husked and placed conveniently in the trees. But because of the "marker," the squirrel is inhibited from doing this, and gathers new ones instead. As a result, an increase in the winter caches is assured.

Photoperiod and odor are two of the cues to which the animal responds, as indicated by these experiments; there are many others, of course. Such cues are continually orienting the animal, resulting in evolved reactions both on the behavioral and physiological level. Such reactions assure the survival of the species by placing the animal in a favorable relationship with its environment. Reactions that fail to do this result in the death of the animal and, on a broader scale, lead to the replacement or extinction of the species in that environment.

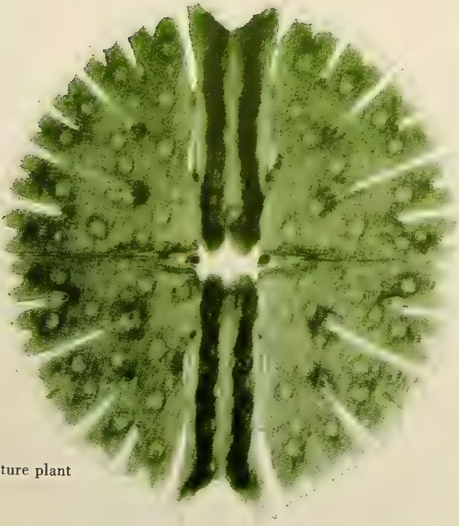






**AT PEAK PERIODS,** captive animals may store more than 300 nuts in one night.

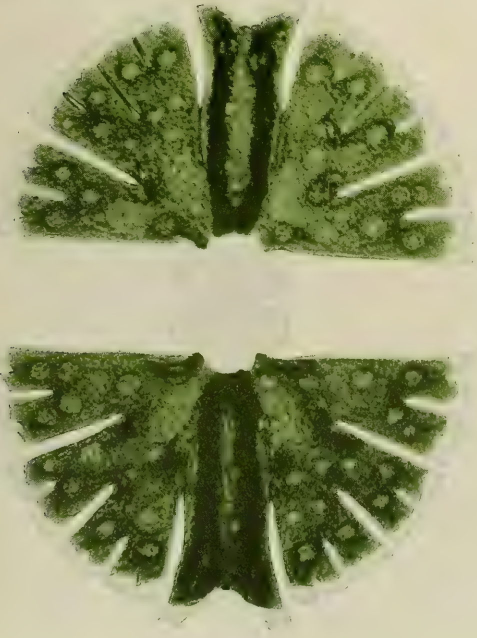
# Green Algae Divide to Multiply

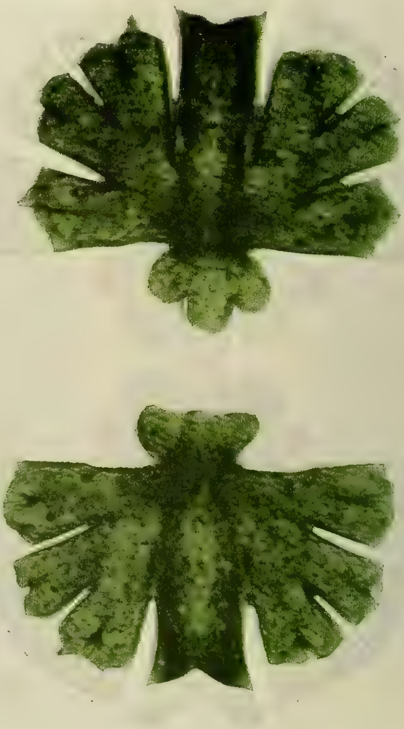

Mature plant

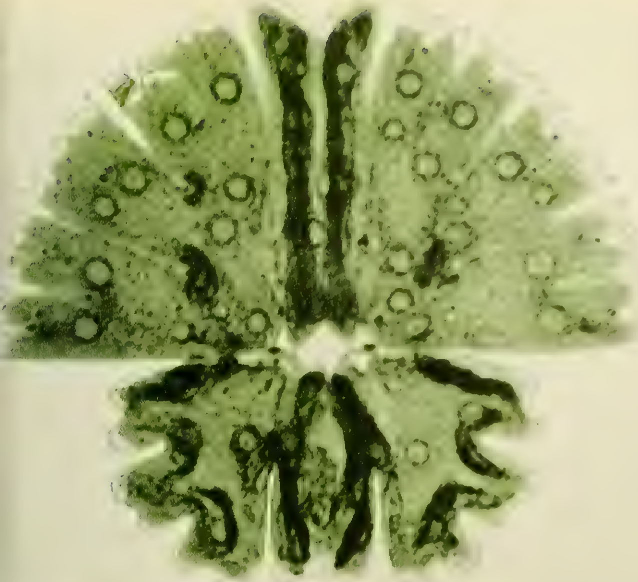
By Winton Patnode

FRESH-WATER green algae can reproduce vegetatively by cell division and growth. *Micrasterias rotata* is a desmid, one of the numerous family of algae that inhabit ponds, lakes, and soil all over the world, exhibiting a great variety of beautiful and intricate forms. The photographs on these pages show living plants as they undergo vegetative reproduction.

Reproduction by cell division is recognized as basic to the growth of all living things. The roots of potatoes or irises, cut in pieces and planted, grow new tops. A leaf cut from an African violet and placed on the surface of moist soil sends down roots and produces a new plant. The strawberry aboveground and the bunchberry


Early stage of division


Late stage of division



independent, half-grown plant

(*Cornus canadensis*) underground send out long runners to make new and independent plants. Many plants reproduce vegetatively by cell division and differentiation to an even greater extent than by sexual propagation through seeds or spores. Modern techniques in color photomicrography, using one-celled algae as subjects, allow one to see this process as it could formerly be seen only by observation through the microscope.

The *Micrasterias* is a tiny one-celled plant (*top left*), about a hundredth of an inch in diameter. It has no roots or stem or flower, but superficially it resembles a leaf. It grows unattached in untold millions in ponds, swamps, and lakes, drifting with winds and currents, a part of the microscopic aquatic life known as plankton (from the Greek word for wanderer). Each plant holds within its porous skin all of the aggregations of molecules necessary to its life, growth, and reproduction. Some of these aggregations, or organelles, can be seen in the photographs. The specimens that are shown here were collected in the Cascade Range of Oregon, but their distribution is almost worldwide.

In common with many of the desmids, this one has a prominent constriction at its middle, called a sinus, which divides the plant into two halves, or semicells, usually identical and mirror images of each other. The tissue joining the semicells, called the isthmus, contains the nucleus of the cell, which in turn contains the chromosomes and other bodies that regulate reproduction and inheritance. The isthmus and the nucleus located in it appear as a light spot in the center of the picture of the mature plant.

Cell division begins with the parting of the nucleus into two new nuclei, each of which then initiates the growth of a complete, new, identical semicell and assumes the management of its old semicell. The picture of the early stage of division (*bottom left*) shows the two new semicells beginning to grow and to push the old semicells apart. The next stage (*bottom right*) shows growth proceeding. The old semicells are pushed farther apart; the new semicells now begin to show green chlorophyll-containing chloroplasts. The two plants, each capable of independent existence, may remain joined for some time, until they are broken apart by agitation of the water or by the jerky motions they are capable of making. The fourth picture shows the half-grown, independent plant, which will gradually mature, live, reproduce itself, and die or be eaten.

Algae have aptly been called "grasses of the waters," for aquatic animals graze on them. The desmids are bite-size for aquatic worms, tiny fish, insect larvae, and other animals. Like other green plants, algae use sunlight to convert minerals, water, and carbon dioxide ($CO_2$) to carbohydrates, fats, and proteins. They are rich in protein and have high nutritive value.

Algae absorb carbon dioxide and release oxygen as part of the photosynthetic process. This oxygen is important in reaerating potable water supplies, supplementing turbulence. It also suppresses activities of anaerobic bacteria that lead to septic or foul conditions. Removal of carbon dioxide from water by algae may also substantially reduce carbonate hardness. An overabundance of algae, however, decays, clogs filters, supports undesirable bacterial growth, and sometimes adds unpleasant odors and taste to the water.

Algae have long interested biologists. In the past century, forms, growth habits, occurrences, and classification have been studied intensively. Research continues on molecular organization and on biochemical processes that control growth, reproduction, and heredity.

Looking to the future, many scientists believe that for extended trips into space man will take along algae gardens to supply food and oxygen and to absorb wastes. Man needs food, water, and oxygen, and expels carbon dioxide and other metabolic end products. By maintaining a man–plant balance in the capsule, some problems of stocking supplies and absorbing wastes may be reduced. With solar energy continuously available, the normal life processes of algae may make such interdependence feasible. This is because some species of algae live in close association with fungi and bacteria, which suggests sophisticated biological systems that might be used in waste reclamation.

In sunlight, algae expel oxygen and absorb carbon dioxide—not in the same proportions needed and discarded by man, but near enough to allow reducing the load of oxygen and $CO_2$ absorbents. The food potential of algae, especially marine varieties, is still unrealized. Algologists and other scientists are working on the idea, and their findings may be a key to future food supplies.

# Mystery of a Millipede

## Hydrogen cyanide gas is made by insect, new studies show

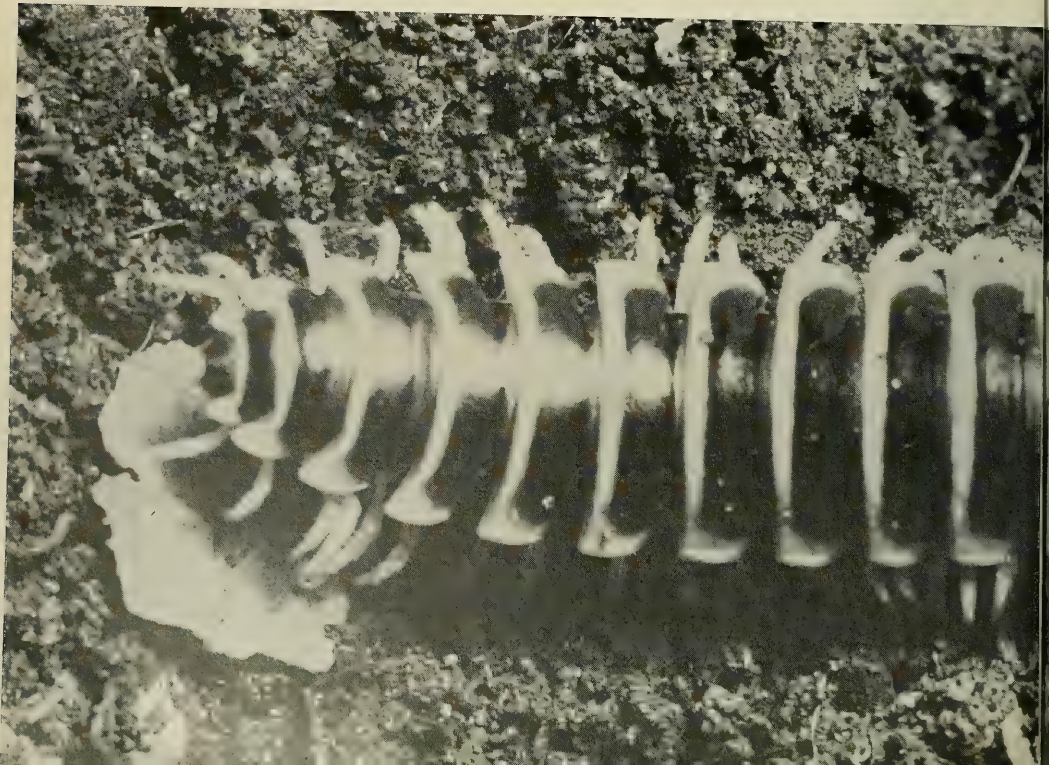
By T. Eisner and H. E. Eisner

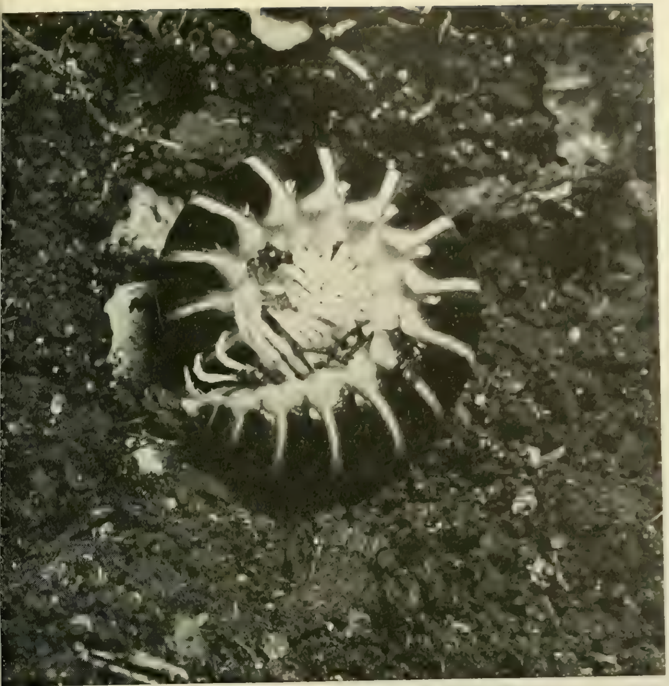
In the entire annals of human crime, perhaps no poison has achieved a more deservedly notorious reputation than hydrogen cyanide. Known also as prussic acid, or simply as cyanide, and endowed with a characteristic odor of "bitter almonds," it is quickly fatal in small quantities. Its toxicity is not restricted to man. In fact, hydrogen cyanide is as nearly universal a poison as one can find. This is because it exerts its toxic action by interfering with certain basic respiratory phenomena upon which most living cells depend for survival.

A most surprising fact is that there actually exist animals capable of producing hydrogen cyanide. Years ago, naturalists found that certain millipedes possess an unmistakable odor of bitter almonds, and they were quick to note that a container with such millipedes could serve effectively as a "killing jar" in which insects and other small animals would not long survive.

In our laboratories at Cornell University, the two of us, together with Rosalind Alsop, Fotis Kafatos, Professor Jerrold Meinwald, and the late Dr. Jeffrey J. Hurst, have recently had the opportunity to study one of these millipedes in some detail. The species involved, *Apheloria corrugata*, is occasionally very abundant in the environs of Ithaca, N. Y., where it can be found from spring to fall in deciduous woods, crawling among leaf litter or hiding under rocks. It is a beautiful, dark-brown animal, variously adorned with yellow and pink markings, and is about two inches long.

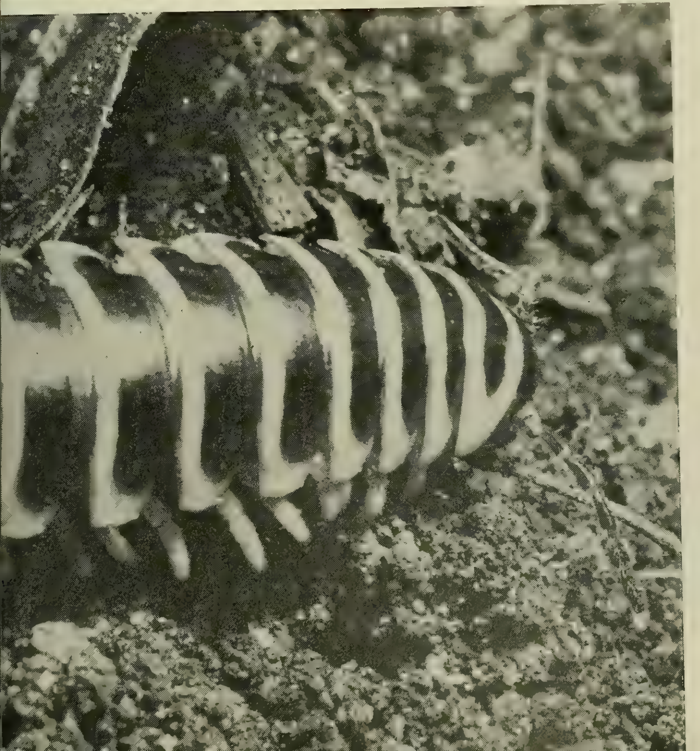
We were curious about several things. First, does *Apheloria* really produce hydrogen cyanide? No previous work had been done with this particular species, and some of the earlier claims based on other millipedes were open to question, since they were not backed by rigorous chemical proof. Second, is the emission of hydrogen cyanide a continuous process, or is the gas released only when the millipede is under attack by predators? The vulnerability of millipedes to their enemies had never been studied carefully, and it seemed obvious that one should test the defensive effectiveness of the poison by exposing *Apheloria* to ants, amphibians, birds, and any other such predators as might share its environment. But perhaps the greatest challenge was the possibility of discovering the exact mechanism whereby the





**Millipede,** *Apheloria corrugata,* may remain coiled in a tight spiral, *above,* after it has discharged a cyanic gas.

**Living** beneath logs and dead leaves, millipedes may be found in deciduous woods. This one is about 2 inches long.



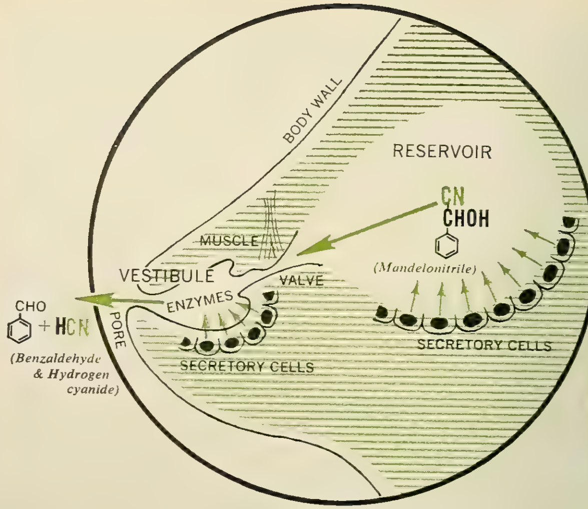
millipede produced its formidable poison. The chemical basis of this mechanism was a complete mystery.

The answer to the first question was quick to come. Groups of *Apheloria* were placed by hand into lidded jars, and a variety of analytical procedures were then used to test for whatever gases had accumulated in the containers. There could be no doubt: hydrogen cyanide was indeed being produced, and the millipedes were apparently not affected by the fumes. It also became clear that the millipedes released their poison only if they had been annoyed beforehand. If they were allowed to crawl into the jars on their own, without being touched in the process, no detectable amounts of hydrogen cyanide were released. It was also noticed that the emission of hydrogen cyanide does not come to an abrupt halt the moment the disturbance ceases. Once a millipede had been handled, it would continue to release its poison for minutes thereafter, even if left completely to itself. The rate of the release was highest at first, and then gradually declined. Whatever the mechanism of discharge, it seemed clear that the animal did not store its poison in some sort of anatomical "bottle," which was being "uncorked" momentarily whenever the animal "felt annoyed." Instead, it appeared that the release of hydrogen cyanide was the result of a chemical reaction, triggered by the disturbance, and forced to run a normal course once it had been initiated.

Thus, we reasoned that the millipede might be doing something similar to what a chemist does when he pours acid on a bicarbonate salt. Carbon dioxide is instantly generated, and continues to evolve as a gas until the salt has been expended. In the millipede, there also need be no more than two compounds involved in the reaction. One of them could be a molecule holding cyanide in some sort of stable combination (that is, a cyanogenic molecule), and the other an enzyme capable of catalyzing the decomposition of the first. The two compounds might be stored in separate adjacent compartments, ready to be mixed at the moment of disturbance. This was our hypothesis. The obvious thing to do next was to examine the anatomical apparatus responsible for cyanide production.

Previous workers had shown that

**Mid-body** segments reveal the opening of the gland and droplets of secretion.



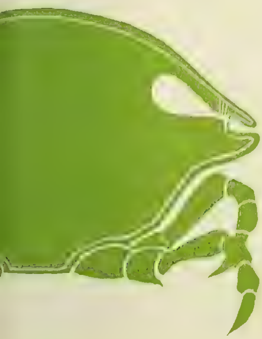
**Reservoir** and vestibule of the gland are joined by a narrow duct, but the contents are divided by a springlike valve that keeps duct tightly closed.

the poison is the product of special glands. A millipede does not possess just one such gland, but a whole battery of them. They are distributed in pairs, one pair per each of most body segments, and their openings are clearly visible as tiny pores on the flattened dorsolateral lobes that project from the body above the legs. When a millipede is irritated, droplets of liquid are seen to ooze from the pores, and from these droplets hydrogen cyanide emanates as a gas.

After carefully dissecting the individual glands, we were able to study their anatomy in detail. What we found delighted us, because it conformed precisely to expectations: each gland was indeed a two-compartmented organ. The larger of the two compartments, which we called the *reservoir*, is a thin-walled sac, ordinarily filled to capacity with a liquid secretion. The smaller compartment—we termed this the *vestibule*—is also liquid-filled and is interposed between the reservoir and the gland opening. Reservoir and vestibule are joined by a narrow duct, but their contents are ordinarily held apart because of a springlike valve that keeps the duct tightly occluded at its junction with the vestibule. Associated with this valve is a special muscle, whose function is obviously to clear the duct by opening the valve.

In order to envision how the gland

**Diagram,** *below*, shows the glands of an *Apheloria*. These are distributed in pairs, one pair for each body segment. Gland openings look like small pores. Chemistry of cyanogenic mechanism is seen in diagrammatic rendering, *left*.

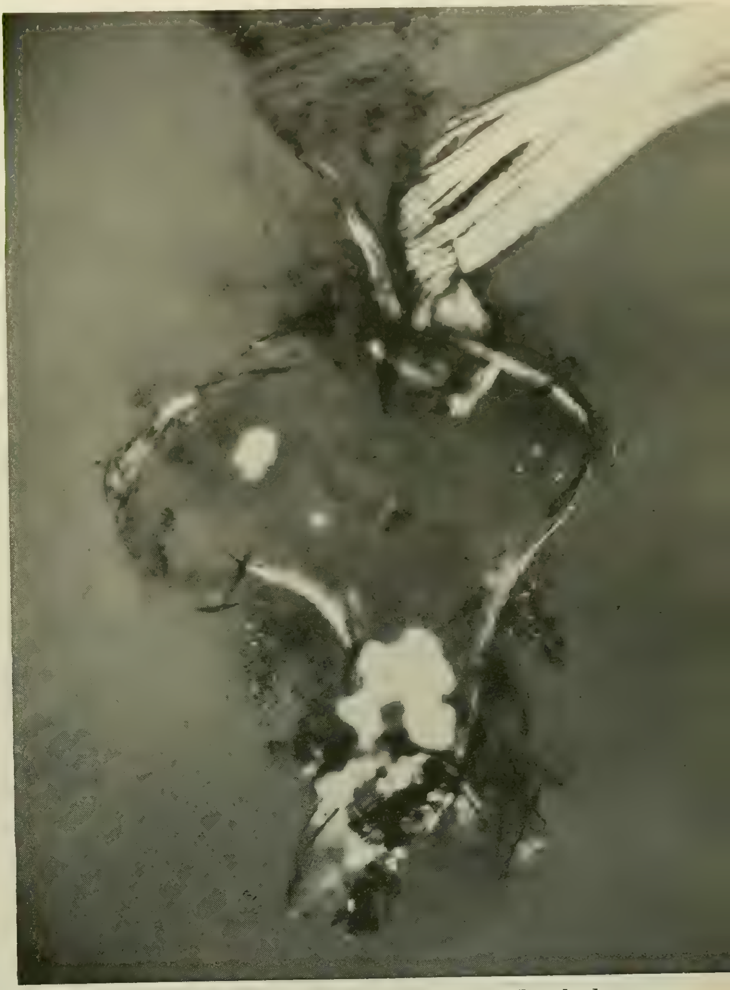


effects its discharge, one need only imagine the simultaneous occurrence of two events: compression of the reservoir, and contraction of the muscle that inserts on the valve. The result is obvious. The secretion in the reservoir, channeled through the vestibule and mixed with its contents, is forced to the outside.

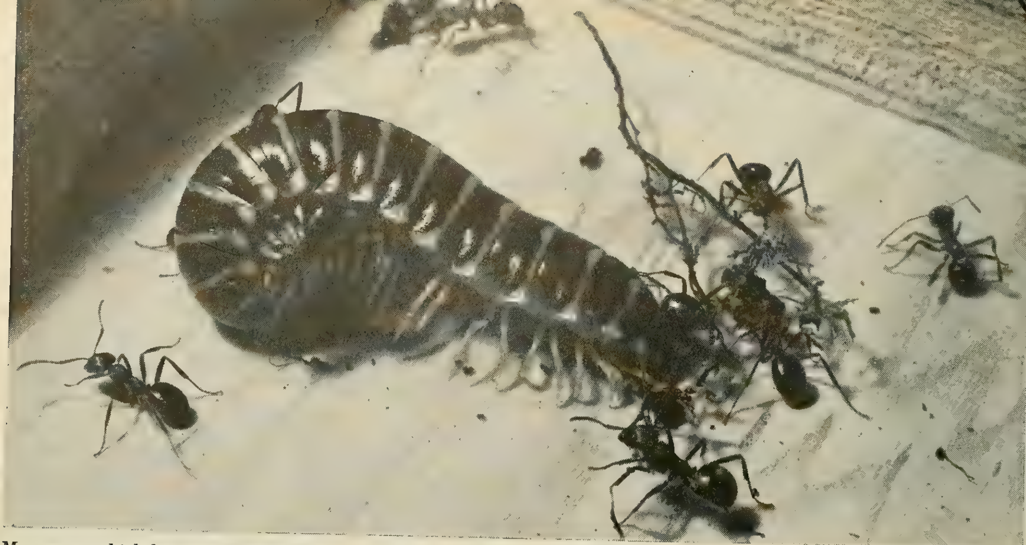
Our hypothesis could now be taken one step further. The reservoir, being the larger of the two compartments, might logically be expected to be the source of the undissociated cyanogenic compound; the vestibule, in turn, could supply the enzyme that catalyzes the dissociation. The droplet that emerges from the gland at the instant of discharge would thus inevitably be a cyanide-liberating mixture.

We already had circumstantial evidence that reservoir and vestibule produce different substances. The secretory cells associated with the two compartments are of very different structure, and it seemed inconceivable that they might be engaged in similar synthetic efforts. The desirable thing would have been to study the contents of the two compartments by direct chemical analysis, but this would have been a laborious task. The compartments are, after all, very small. Even the "large" reservoir measures only about 0.7 mm. in its longest dimension, and it usually holds less than 0.001 ml. of fluid. However, after excising the individual compartments through careful dissection and draining their contents on filter paper, a variety of "spot tests" were made that yielded valuable information. For instance, we added to the droplets of secretion minute amounts of chemical indicators sensitive to cyanide, and observed (with a microscope) the resulting color reactions that developed on the filter paper. This showed that neither the contents of the reservoir, nor those of the vestibule, ordinarily release hydrogen cyanide. But if the compartments were drained together on the paper, mixing their contents, cyanogenesis began at once.

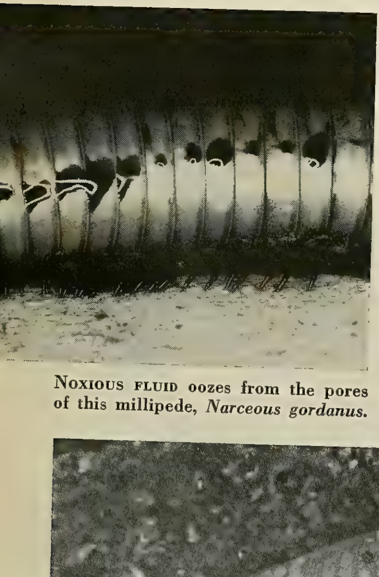
Other tests were made in which special enzymes were used that are known to promote the dissociation of certain types of cyanide-containing molecules. Added to the droplets of secretion, these enzymes caused liberation of hydrogen cyanide from the contents of the reservoir, but not from those of the vestibule. This and other similar tests proved conclusively that the reservoir is the source of the undissociated cyanogenic precursor, while the vestibule supplies the factor (presumably an enzyme) that triggers cy-



**Muscle-operated** valve can be clearly seen in this highly magnified picture of the vestibule. When the duct opens, chemicals combine to form poison gas.



**Millipede,** which has not emitted gas, is attacked by a colony of ants, *above.*



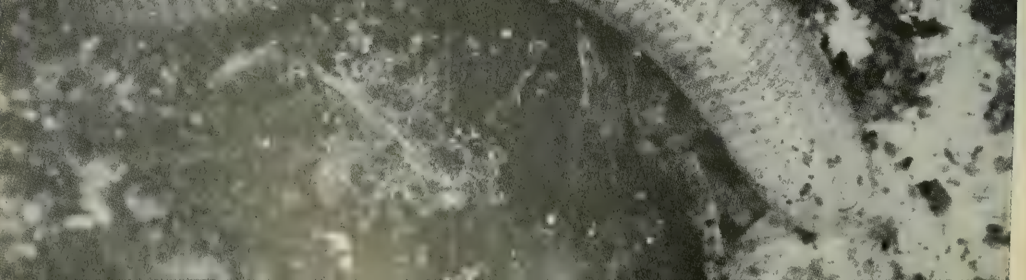
**Noxious fluid** oozes from the pores of this millipede, *Narceous gordanus.*

anogenesis. The hypothesis seemed to be confirmed once again.

Our next attempt was to identify the cyanogenic compound in the reservoir. We are not a particularly patient lot, and the prospects of dissecting hundreds of reservoirs for chemical analysis appealed to no one. We decided instead to concentrate our efforts on the discharged secretion, on the assumption that the basic framework of the cyanogenic molecule would remain as an intact residue even after cyanide liberation had run its course. We had to collect massive amounts of secretion, but "milking" millipedes is no unpleasant task. Capillary tubes are simply pressed against the gland openings, and the millipede responds in a co-operative fashion by shooting its secretion into the tubes.

The analysis revealed the presence of a compound, benzaldehyde, which indeed has the ability to bind cyanide. The combination, mandelonitrile, appeared to be the molecule we were after. To clinch matters, additional analyses were made on discharged secretion that was only minutes old. Enough undissociated mandelonitrile was still present in this sample to permit its positive identification. This is as far as we took our chemical work, and the story is summarized in the ac-

**Secretion** with the odor of camphor is produced, *below,* by a *Polyzonium* sp.



companying diagram. Cyanide production in *Apheloria* is evidently a most elegant mechanism. Hydrogen cyanide would be very difficult to store as such. It is highly toxic, and awkward to "bottle" because of its high vapor pressure. Mandelonitrile permits the animal to store its poison in a stable form, withheld until its dissociation is triggered by the discharge.

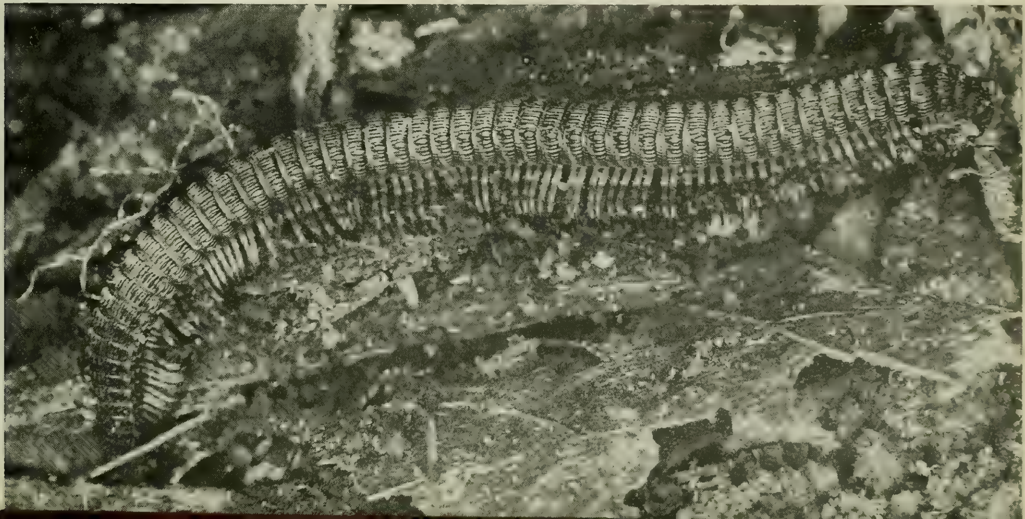
*Apheloria* can exercise remarkable control over the operation of its defenses. When it is disturbed, it does not usually discharge from all glands at once, but only from those closest to the region of the body subjected to disturbance. Thus, when a single leg is stimulated, say by pinching it gently with forceps, only the gland nearest that leg will eject secretion. Similarly, when two or three legs are pinched simultaneously, then only the two or three glands next to these legs are brought into action. Only when the entire body of the millipede is handled persistently and roughly are all glands discharged synchronously. The animal is evidently adapted to cope not only with large predators, which can probably be repelled only by a multiple dose of secretion, but also with smaller predators such as ants, in response to which it might be superfluous and wasteful to discharge from more than a few glands at a time. But the real effectiveness of the glands did not become apparent until we exposed millipedes to actual predators.

We usually have in our laboratories captive colonies of ants, which we use for a variety of experimental purposes. The colonies are housed in glass cages, but the ants have access to large wooden platforms that serve as their foraging arenas. It was on these platforms that we staged the "battles" between ants and millipedes. No sooner was a millipede released in the arena, than the ants rushed upon it, biting its legs with their mandibles, and otherwise assailing it from all quarters. The millipede made no effort to flee. Quite to the contrary, it usually came to an abrupt halt, typically with its front end coiled ventrally beneath the body. Next a dramatic thing happened. The entire ant swarm suddenly dispersed, the individual ants fleeing aimlessly in all directions. During their escape they were seen to drag their mouthparts against the substrate, in an obvious attempt to cleanse themselves. Each had evidently received a "dose" of poison, and the millipede—its back now glistening with the droplets of secretion that had oozed from its glands—was free to make its escape. For minutes thereafter, it remained invulnerable to further attack. Ants attempting to approach it would at once turn and flee, in obvious avoidance of the poisonous fumes. Even as long as twenty minutes after discharge, the ants would still be repelled by direct contact with the millipede.

This prolonged invulnerability was puzzling at first, since by the end of the twenty minutes the discharged mandelonitrile should have completed its dissociation and hydrogen cyanide liberation come to an end. However, it could be shown that the residual benzaldehyde is also obnoxious to ants and, since it evaporates rather slowly, remains on the millipede as a persistent repellent that outlasts the initial cyanogenic phase of the discharge. Thus, the millipede is equipped, as it were, with two lines of defense. At first, it relies primarily on the action of hydrogen cyanide, which keeps ants at a distance, and later it depends on benzaldehyde, which repels them on contact. Twenty minutes is a considerable period of time, obviously long enough for the millipede to make its escape. Prolonged invulnerability could be of particular importance where predators such as ants are involved, as they are likely to attack in groups rather than singly. The alternative—short-range invulnerability—could place the millipede in the predicament of being forced to deplete its entire secretory supply in a quick sequence of discharges, and it might never survive the first attack by an ant colony. This is of particular importance, as it takes several days for a totally depleted gland to refill.

Actually, *Apheloria* does not always escape after a discharge. When the animal is handled, it often coils its entire body into a tight spiral, and it may remain in this condition for some time after discharging (thirty seconds is not unusual), even if left to itself and no longer molested. It is as if the animal, in "anticipation" of further disturbance, was seeking shelter within the repellent cloud of its own poisonous fumes. If a coiled millipede is poked at intervals, it may remain coiled indefinitely. This behavior has obvious survival value for an animal that lives in cramped habitats—

**Phenol** is secreted by this ***Abacion magnum*****,** **a millipede about 7 cm. long.**



under rocks, logs, in leaf litter—where escape might be difficult, but where the vapors of the secretion are likely to accumulate rather than dissipate.

Additional tests were made in which individual *Apheloria* were exposed to only a few ants at a time. This served to confirm what we already suspected from having irritated the millipedes manually: a localized traumatic stimulus elicits only a localized response from a few appropriate glands. Whenever an individual ant was observed to bite a millipede's leg, the ensuing discharge was invariably restricted to the gland or glands nearest that leg.

*Apheloria* is also protected against amphibians. Toads to which the millipedes were offered promptly pursued them and struck at them in typical fashion with their sticky tongues. But the millipedes were usually not swallowed. In what often amounted to a most grotesque gesture, the toad would spit out the millipede, as at right, and then, in obvious discomfort, would sometimes be left "pawing" its tongue with the front feet.

OTHER predators, which included carabid beetles, blue jays, armadillos, opossums, and skunks, were also tested. All of them showed some "dislike" for the millipedes. Their discrimination was not always absolute, but usually, if offered a choice between *Apheloria* and more palatable prey, their preference was for the latter. (If offered only a millipede, they usually rejected it, although sometimes they ate a portion of it.) All the evidence seemed to point to the very considerable effectiveness of *Apheloria*'s defenses. Still, we know from having found dead millipedes in nature with injuries that were clearly predator-inflicted, that some of them do succumb to attack. We never discovered the predators involved, although we suspect that in a number of cases they were rodents.

Millipedes are a very diverse group, and not all of them produce hydrogen cyanide. However, the overwhelming majority do have glands, situated in pairs along their bodies as in *Apheloria*, and similarly serving for defense. Their secretions have been the subject of some research, both in our laboratories and elsewhere, and it is becoming increasingly apparent that the active principles they contain are of very different kinds. There are, for instance, certain millipedes that produce benzoquinones, a most toxic group of compounds, with vapors that are highly irritating to the exposed surfaces of the face, and to the eyes in particular. These quinones have the peculiar ability of tanning human skin, and many a collector of millipedes is aware of the purple color his fingers are likely to assume after a day's hunt. Other millipedes produce *p*-cresol, a phenolic compound with strong odor that is powerfully repellent to predators. Still others produce a secretion with an odor unmistakably reminiscent of camphor. We are currently studying this secretion, but have yet to identify its constituents (we do know that camphor is *not* present). Finally, there are some millipedes that apparently have no glands. We recently received some of these from South Africa. Interestingly, they coil up tightly when disturbed, in much the same fashion as do the familiar sow bugs and the armadillos. They differ

**TOAD** violently rejects one millipede that it has just struck with its tongue.

from millipedes such as *Apheloria* in that not a single appendage is exposed when they are coiled; they are virtually invulnerable to ants, which can find no hold for their mandibles. This snug coiling is obviously a defensive behavior, and makes up in part for the lack of glands.

There is a point worth mentioning concerning those millipedes that produce non-cyanogenic secretions. Their glands resemble those of *Apheloria* in that they have a reservoir, a duct that drains it, and a terminal valve operated by a single muscle. But they have no trace of a vestibule. This second compartment is absent apparently because the compounds discharged by these glands (quinones, phenols, etc.) are stored as such in the reservoirs, and do not require chemical activation at the moment of ejection.

There is still much to be learned about the defenses of millipedes. Perhaps some day, when we know more about them, it will be possible to reconstruct the obviously elaborate evolutionary history that led to the diversification of the glands and their secretions. Millipedes are an all too often neglected group of animals and what we do know about their biology is pitifully meager. Even *Apheloria* has left us with several critical questions unanswered. Why is it that this animal is apparently completely insensitive to cyanide? After a discharge it is literally immersed in its poisonous fumes. How does it cope with the cyanide that must inevitably seep into its body through the respiratory system. As yet, we do not know.

# SKY REPORTER

## Andromeda galaxy dominates our view of distant universe

By Thomas D. Nicholson

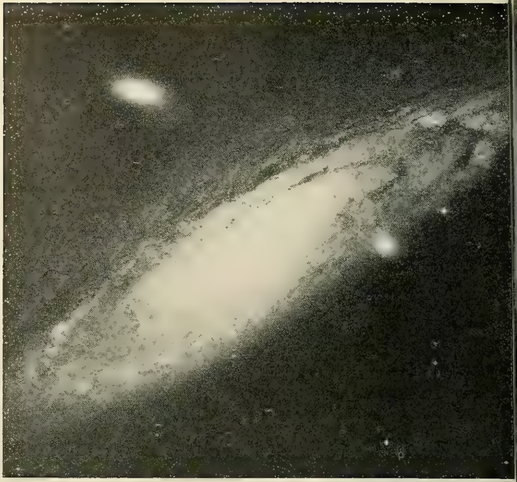
In our discussion last month, we saw that our Galaxy, the Milky Way, is truly an island of stars in the universe, surrounded by empty, starless space. But across that space, at distances measured in millions of light-years, there are other islands like our own, other galaxies of varying sizes, shapes, and distances. They surround our Galaxy in every direction in the universe and for as far as we can see into that universe.

There are hundreds of millions of these exterior galaxies, and each has its own population of billions of stars. Although all are immense and brilliant objects, shining with the combined brightness of their individual stars, they are so distant from us that only a few can be seen without the aid of a telescope.

One of these few is dimly visible as a faint, oval haze in the direction of the constellation Andromeda. In late March it is visible low in the northeastern sky just before dawn, while in the early evenings of the autumn it is seen high—almost overhead—in the sky. Because we see it in the same direction as we see the stars of Andromeda, we call the object the Great Galaxy in Andromeda. However, it is not really among the stars that make up that constellation. We see it through and beyond those stars and through the starless space that surrounds them.

It is this object—the Great Galaxy in Andromeda—that The American Museum-Hayden Planetarium astronomers have chosen as the Seventh Wonder of the Universe. It is not the largest galaxy we know, nor is it the nearest. But it is the nearest of those giant galaxies that are almost equal in brightness and mass to our own, and it is the only exterior galaxy in northern skies visible to unaided eyes. It is also the most impressive object of its kind that astronomers have photographed from earth. And the Great Galaxy in Andromeda is of tremendous historical significance in astronomy, for it was the first such object to be definitely identified as being outside of the Milky Way.

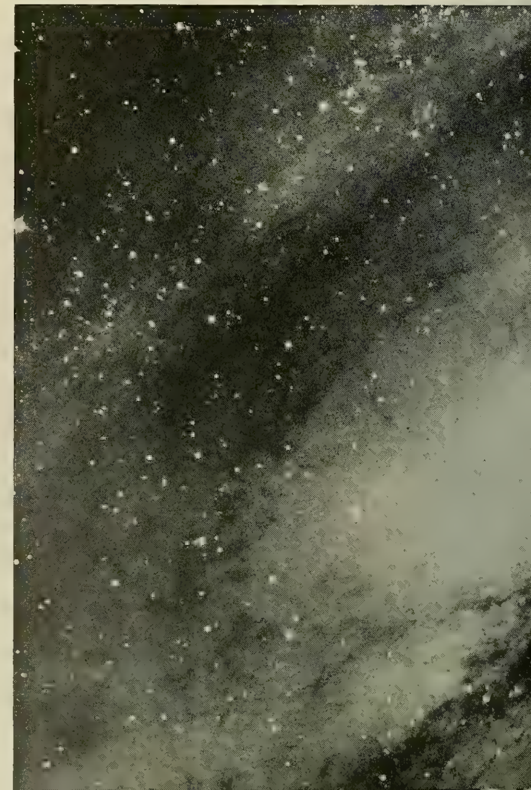
Until the early 1920's, there was no clear evidence whether the faint, oval object seen among the stars of Andromeda (and other similar ones observed telescopically in other parts of the sky) was a very distant object among the stars of our Galaxy or whether it was beyond the Milky Way. Until then, such objects were still classed as nebulae —a term referring to any indistinct, extended region of brightness seen among the stars. However, many astronomers suspected that these bodies were made of stars, not of gas and dust clouds. In their spectra, they exhibited the same kind of absorption lines as star clusters, and also showed emission features similar to those of gaseous nebulae. Novae, explosive stars that increase quickly in bright-

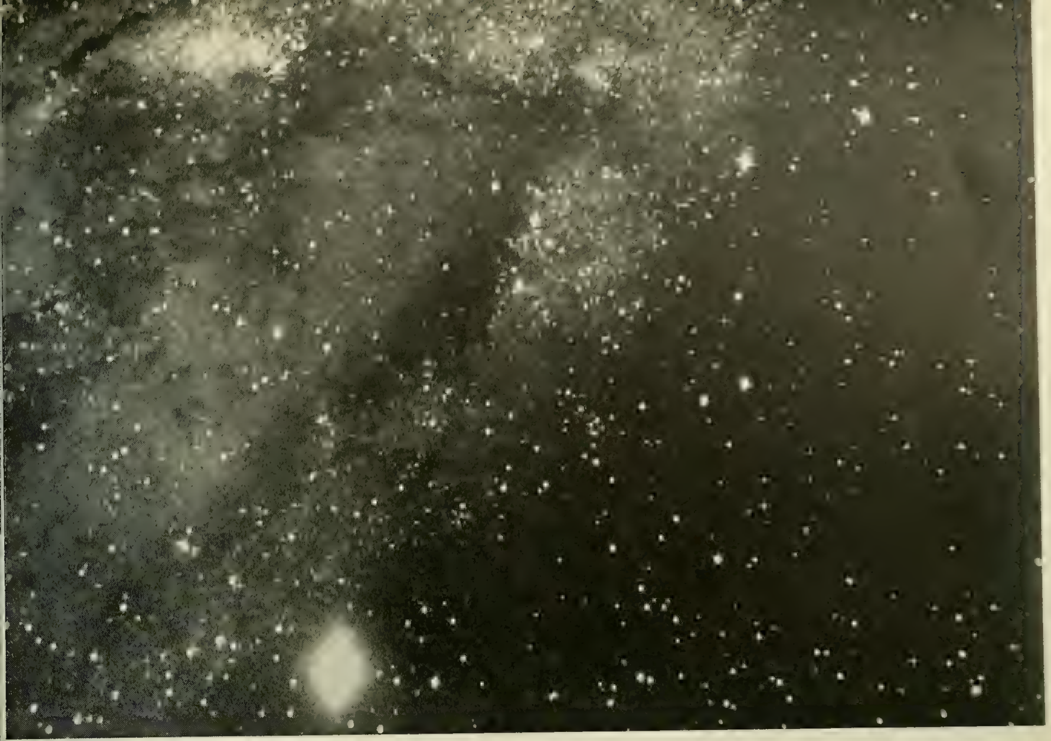


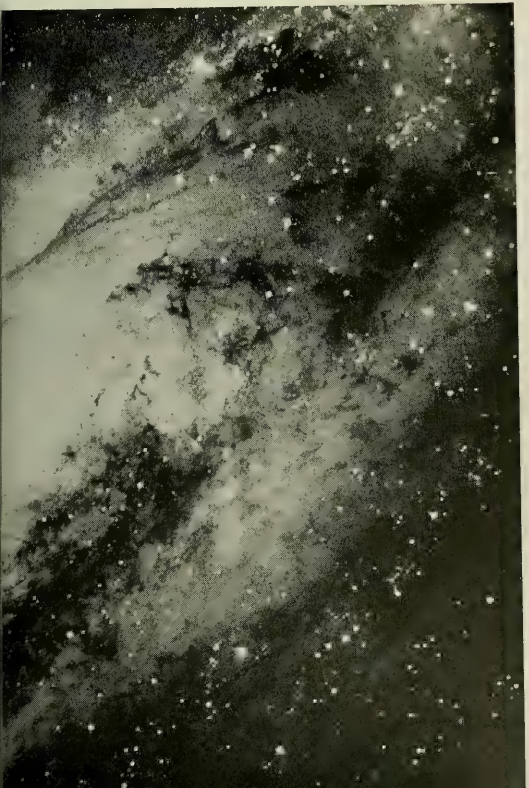
**Great Galaxy** in Andromeda, *above*, is close in size to the Milky Way. Two small, bright masses are satellite galaxies.

**Small** bright foreground stars, *right*, are in constellatio Andromeda. Nebulous patches beyond are arms of galaxy

**Center region** of the galaxy, *seen below*, shows the narrow lanes of dark gas extending from the arms to the nucleus.







ness, were often observed in them. And, subsequent to 1918, when the 100-inch Hooker telescope went into operation on Mount Wilson, California, a few—principally the object seen in Andromeda—were at least partly resolved into what looked like individual stars. Since many were observed to have a spiral structure, they were called spiral nebulae to distinguish them from other, clearly gaseous nebulae that were seen among the stars of the Milky Way.

THE debate on the nature of the spiral nebulae was finally resolved by Edwin P. Hubble, of the Mount Wilson Observatory. Over a number of years of observation with the 100-inch telescope, Hubble was able to take photographs of the spiral nebula in Andromeda, and he observed what appeared to be clear, starlike condensations in the outer parts of the spiral structure. Then, in photographs taken in 1923 and 1924, Hubble found in several of these starlike spots changes of brightness that matched the light variations in certain classes of stars observed in the Milky Way. He proceeded to establish without question that these were Cepheid-type variable stars, and that their light period (the interval in which they repeated their fluctuations of brightness) established their absolute magnitudes, as it did for similar stars within the Milky Way. Absolute magnitude is a measure of the true brightness of a star, but its brightness as observed from the earth—called apparent magnitude—may be considerably less because of the dimming effect of distance. When Hubble measured the apparent magnitudes of the variable stars in the spiral nebula, he was able to determine the distance to the stars and thus to the object in which they were located.

**Galaxies** clustered in Hercules appear in many positions. Elongated bright streaks are spiral galaxies seen edge-on.

In 1924, Hubble derived a distance of 900,000 light-years for the spiral nebula in Andromeda. As we saw in the February "Sky Reporter," the Milky Way extends no more than about 70,000 light-years from us in any direction. The distance derived by Hubble showed that the spiral nebula was located far outside of the Milky Way, and that it was actually a separate island of stars in the vastness of the distant universe. At the distance he estimated, however, the spiral in Andromeda would have been about 30,000 light-years in diameter, considerably smaller than the Milky Way. It appeared, at least for a time, that if the spiral object in the direction of Andromeda were indeed another "island" universe, then ours must be a "continent" universe.

The apparent difference between the spiral nebula in Andromeda and our own Galaxy was resolved in time, partly because estimates of the size of our Galaxy were revised downward from Shapley's early work and partly because the distance to the spiral nebula in Andromeda has been revised upward several times since Hubble's first estimate in 1924. Each revision of distance proportionately increased the size of the object that we observed until, with the revisions in the extragalactic distance scale calculated by Walter Baade in 1952, the size of the object in Andromeda became comparable with the size of the Milky Way itself. This removed the last vestige of doubt in the minds of astronomers; the system of stars that they observed in Andromeda was a galaxy like our own, comparable in every way. It was no longer appropriate to refer to it as a spiral nebula, although in tribute to tradition this designation is still sometimes used. The nebula had become a full-fledged galaxy, and as such it has since been described properly in the literature—the Great Galaxy in Andromeda.

The other spirals also eventually were known as other galaxies, although the term galaxy is not restricted to objects that exhibit a spiral form. Many galaxies are irregular in form, with no evidence of similar structure at all, and many others are spherical or elliptical in appearance. Even the spirals themselves vary widely in structure, from those with only two loosely curving arms of stars to others with multiple arms so tightly wound that it is difficult to distinguish them. The term galaxy does not refer to any object of any specific size or shape or structure, but rather to an island of stars in the universe, separated from the other islands of stars by vast stretches of starless space. So far as we have yet determined, the galaxies are the basic building blocks of the universe. It is into galaxies that stars, gas, dust, and planets—if planets are present in galaxies other than our own—are organized. The distances between galaxies are so great as to be almost incomprehensible.

When we began our series last August on The Seven Wonders of the Universe, we said that the objects were chosen so that, among other things, they would represent the architecture of the universe, so far as we presently know it. Now, seven months later, it may be interesting to see how well we have done.

We started with the face of the moon, about a quarter of a million miles from the world we live on. Then we looked at the rings of Saturn, located in the solar system, about 1,000 million miles from the earth. Next we selected a field of stars and interstellar gas—the Orion region—where the stars are separated by distances of 25,000,000 million miles or more. In Orion, we found evidence of the birth of stars, and then, in the Crab Nebula, we saw the events that accompany the death of a star. The Fifth Wonder was the Globular Cluster in Hercules, and we saw how the system of globular clusters identified our position in the galaxy in which we live, the Milky Way. This was the Sixth Wonder, the island of stars in the universe that we call our Galaxy. And finally we have looked beyond our island of stars and the space around it and found another island similar to ours.

This Seventh Wonder, the Great Galaxy in Andromeda, has shown us something of the fundamental structure of the universe, where other galaxies, similar to ours, are separated by distances of 10,000,000,000,000 million miles.

In closing the series, we might consider what we could choose as the Eighth Wonder, if we should search for it. Is the universe we now observe only a part of an even larger cosmos? Some astronomers have speculated about the possible existence of a metagalaxy, as this larger structure might be called. There are objects of a nature that we still do not understand in the universe, such as the objects we call quasars—not clearly stars or galaxies, but seeming to possess some of the properties of each. We do not yet know, but neither should we assume that our present knowledge of the universe represents the end of the search. If there is one thing that the astronomy of past centuries has taught us, it is that there is much more to learn.

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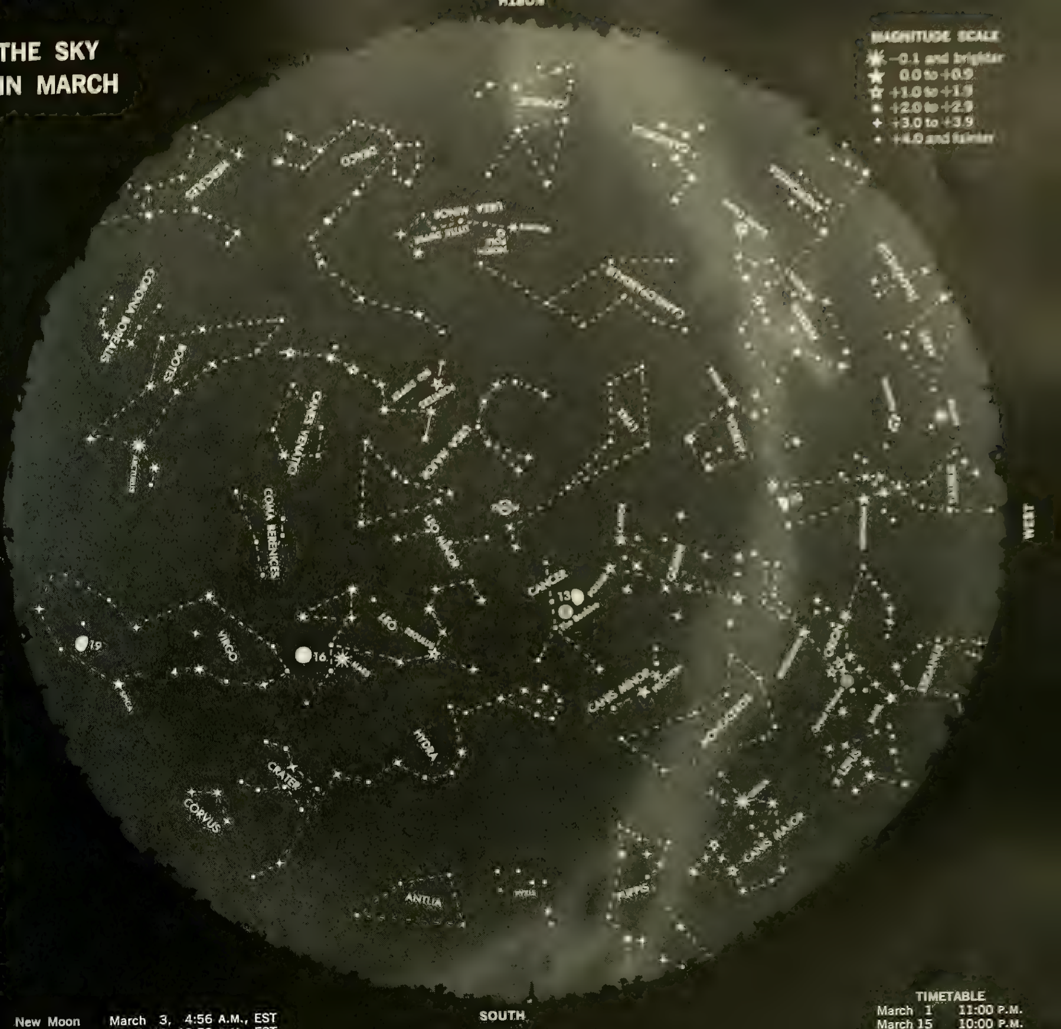
**Dr. Nicholson** is Assistant Chairman, Astronomer, and a lecturer at **The American Museum-Hayden Planetarium.**

# THE SKY IN MARCH


NORTH
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
EAST
WEST
SOUTH
DRACO
URSA MINOR
CORONA BOREALIS
BOOTES
ARCTURUS
CANES VENATICI
COMA BERENICES
URSA MAJOR
LEO MINOR
LEO
REGULUS
MARS
16
VIRGO
SPICA
19
HYDRA
CRATER
CORVUS
ANTLIA
PYXIS
PUPPIS
CANCER
13
POLLUX
CANIS MINOR
PROCYON
ORION
LEPUS
CANIS MAJOR

| | | |
|---|---|---|
| New Moon | March 3, | 4:56 A.M., EST |
| First Quarter | March 10, | 12:52 P.M., EST |
| Full Moon | March 17, | 6:24 A.M., EST |
| Last Quarter | March 24, | 8:37 P.M., EST |

TIMETABLE

| | |
|---|---|
| March 1 | 11:00 P.M. |
| March 15 | 10:00 P.M. |
| March 31 | 9:00 P.M. |

(Local Mean Time)

March 7-8: Jupiter and the moon reverse positions in the evening sky on these nights. On the 7th, the moon is to the right (west) of Jupiter; they are in conjunction at 10:00 A.M., EST, on the 8th, and on the evening of the 8th, the moon appears to the left (east) of Jupiter.

March 9: Mars is at opposition this morning, in line with earth and sun, but in the opposite direction from the sun.

March 11: Mars is nearest earth at 8:00 P.M., EST, at a distance of about 62,100,000 miles. This is about the greatest distance that earth and Mars are separated when they are at opposition.

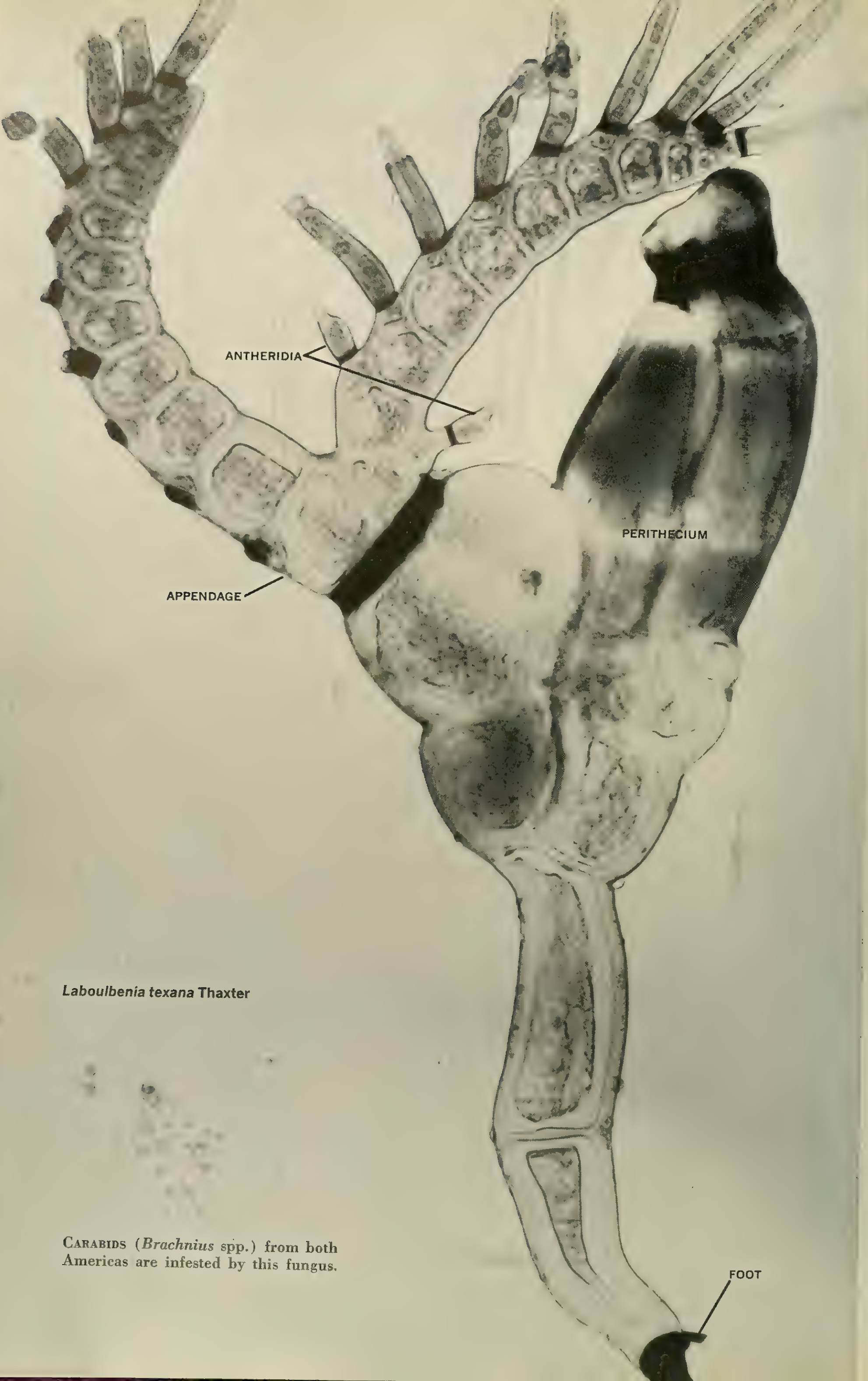
March 16: An occultation of the moon and Mars occurs today, but only in Arctic regions, including portions of Alaska. For the rest of the world it appears as a close conjunction about noon, EST, with Mars slightly south of the moon. In the evening, Mars will be the bright red object to the right (west) of the nearly full moon.

March 20: The sun arrives at the vernal equinox at 3:05 P.M., EST, and spring commences in the Northern Hemisphere, while autumn begins throughout the Southern Hemisphere.

March 21: For several nights before and after this date, observers may see Mercury as a bright object (magnitude near zero) in the western sky after sundown. Mercury reaches greatest easterly elongation from the sun this evening. This is a favorable elongation, since the planet does not set until an hour and three-quarters after sunset.

March 30: Saturn may be seen as a morning star just before sunrise in the eastern sky. Saturn and the moon are in conjunction at 8:00 A.M., EST. Look for Saturn above and to the left of the crescent moon in the east just about dawn this morning.

Jupiter and Mars dominate the evening sky this month. Jupiter appears in the southwest as darkness comes on, and it sets before midnight. In Taurus, it has a magnitude of about −1.8. Mars is in the sky all night during March. It rises about sunset and appears as a reddish star of about magnitude −1.0, and is in the south about midnight, setting at dawn. Mercury may be seen for about a week as an evening star, and Saturn, at month's end, is observable as a morning star.


ANTHERIDIA
PERITHECIUM
APPENDAGE
FOOT

***Laboulbenia texana*** **Thaxter**

CARABIDS (*Brachnius* spp.) from both Americas are infested by this fungus.

# Study in Specificity

## Minute fungi parasitize living arthropods

By Richard K. Benjamin

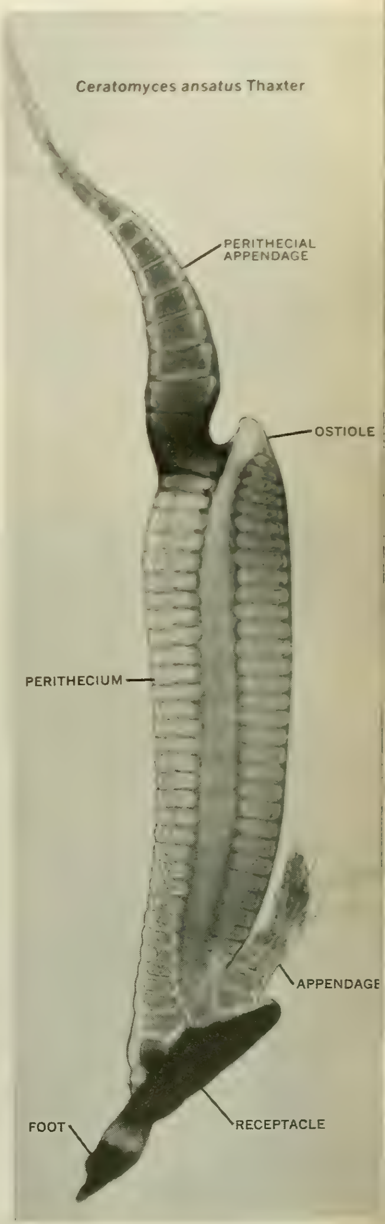
The order Laboulbeniales is a well-defined, yet extremely diversified, group of minute parasitic fungi that develops only on the integument of living arthropods—mostly true insects and mites. All members of the order are relatively small and inconspicuous. Some consist simply of a few definitely arranged cells bearing one or more reproductive structures, and in only a few species do individuals exceed a length of one millimeter. Most species of Laboulbeniales are restricted to a single host species or a few closely related species. Some are able to grow only on a very limited area of the host body, and several are known to infect only the male or female of the host, never both. In number of species, this group of fungi eventually may prove to be the largest in existence, yet it is well known only to a few professional mycologists. Surprisingly, these fungi rarely have attracted the serious attention of entomologists. The latter, however, have been largely responsible for the collection of much of the material upon which our understanding of these remarkable organisms is based. None of these fungi is known to do any serious damage to its host, and they apparently play no part in controlling insects in nature.

*Laboulbenia rougetii* Montagne & Robin, the first species of the order to be described, was correctly placed among the pyrenomycetous fungi by the Frenchmen Jean Montagne and Charles Robin in 1853 when they jointly published its description. The name, like those of many plants and animals, is commemorative and honors two contemporary French entomologists, Alex Laboulbène and Auguste Rouget. In the 1840's these men were known to have observed similar fungi growing on insects. Both, however, viewed the organisms only as possible plant parasites of uncertain relationships and they did not name or attempt to classify any of the forms they encountered. Indeed, there were some biologists during this era who believed these objects were nothing more than abnormal excrescences of the insects themselves.

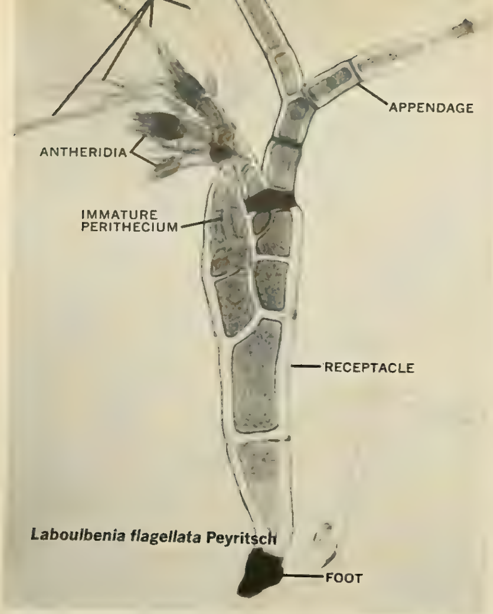
During the following three decades several additional species were described, and the first serious taxonomic studies were carried out by J. Peyritsch, a German, in the early 1870's. In 1873, Peyritsch formally characterized the Laboulbeniaceae, one of the three families of the order generally recognized at the present time. In 1890, there appeared the first of a long series of studies by the great Harvard mycologist R. Thaxter. During the next forty years, Thaxter published numerous papers and five magnificently illustrated monographs in which he described 95 of the 113 genera recognized by the writer, and some 1,250 of the approximately 1,500 species now known.

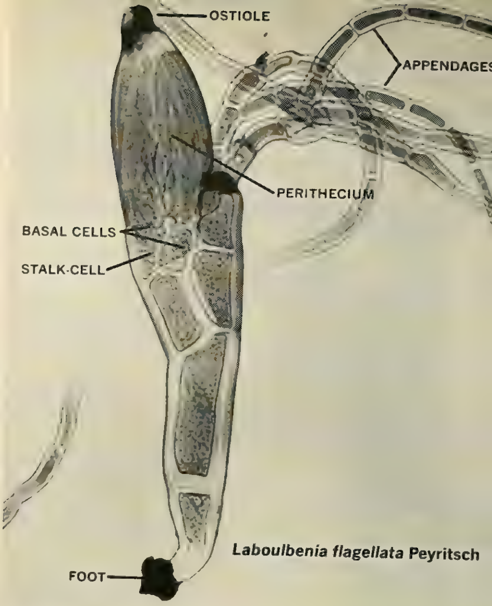
As members of the class Ascomycetes, all true Laboulbeniales reproduce by spores formed in special saclike structures called asci. These are borne within usually elongate, flask-shaped structures, termed perithecia, that have a single apical opening through which the ascospores emerge when mature. In many species the opening, or ostiole, of the perithecium is subtended by one or more outgrowths, or "trigger organs," thought to play a role in spore discharge when contact is made with a new host. Although there is an almost unending diversity of form among the fruiting bodies in the various genera, there is a remarkable uniformity in the structure of the ascospore. Typically, it is elongate, somewhat acicular (needle-like), and two-celled. Four or eight ascospores, depending on the species, are formed in each ascus.

Spore transmission in these fungi apparently is brought about mostly by direct contact of an infected host with another host. With regard to its subsequent development on the host, the ascospore, prior to discharge, is oriented in the perithecium with its usu-



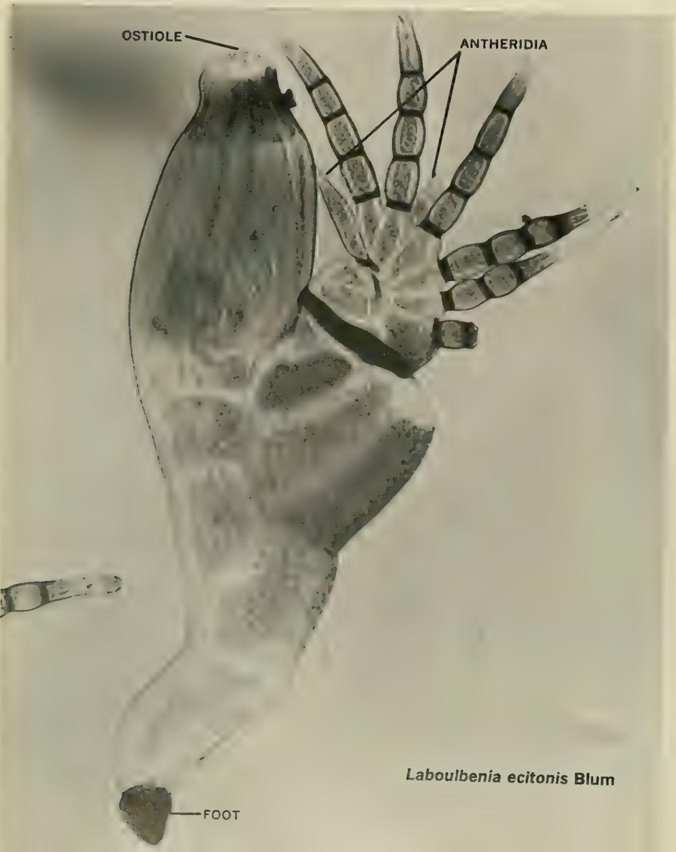
**Many cells** in each row of wall cells in perithecium characterize this genus.


ANTHERIDIA
APPENDAGE
IMMATURE PERITHECIUM
RECEPTACLE
Laboulbenia flagellata Peyritsch
FOOT


OSTIOLE
APPENDAGES
PERITHECIUM
BASAL CELLS
STALK-CELL
Laboulbenia flagellata Peyritsch
FOOT

IMMATURE INDIVIDUAL, *above*, and mature, *right*, represent one in about 400 species in the large genus *Laboulbenia*.

Genus has wide host range and has been found on members of six orders of true insects and on one family of mites.

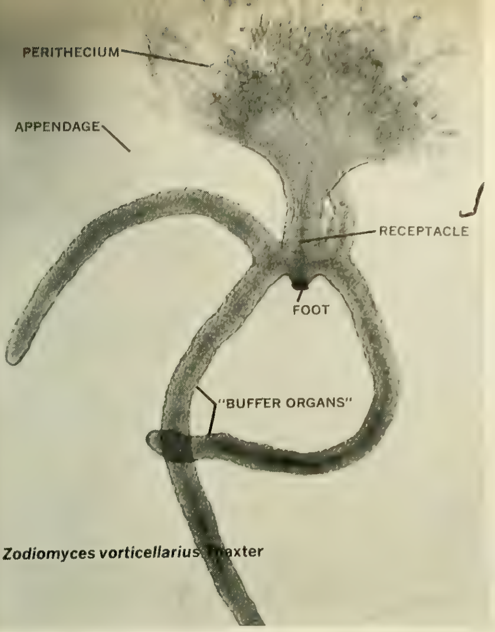

OSTIOLE
ANTHERIDIA
Laboulbenia ecitonis Blum
FOOT

BRAZILIAN ANT, two species of mites found on that ant, plus a beetle that lives in the ant's nest are all hosts to *Laboulbenia ecitonis* Blum, *left*.

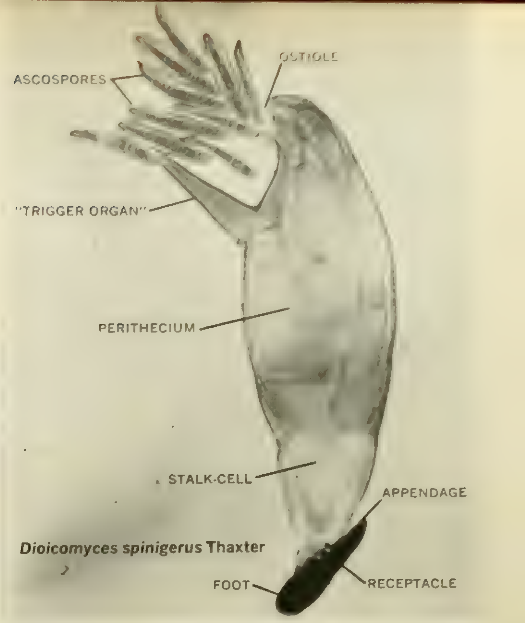
ally longer basal cell uppermost. Thus, when spore transmission is effected the basal cell actually contacts the host first. Also, the spore is surrounded by a thin, gelatinous sheath that probably protects it following discharge and assists in affixing it to the host.

SPORE germination, which in some instances may begin within the perithecium, consists simply of the formation by the basal cell of a sucker-like, often blackened organelle—the foot. When favorably situated on a susceptible host, the foot produces a tiny rhizoidal process, a rootlike filament called the haustorium, that perforates the cuticular layers of the host insect's integument. With rare exceptions the haustorium appears to penetrate no farther than the living cells of the epidermal layer immediately below the cuticle. In a few species that grow on soft-bodied insects such as flies, a simple or branched rhizoid may invade deeper tissues of the host.

Following spore germination, the fungus body, or thallus, develops. In the Laboulbeniales this is unlike that



Elongate "buffer organs" apparently serve to hold body of fungus erect on surface of water scavenger beetle hosts.



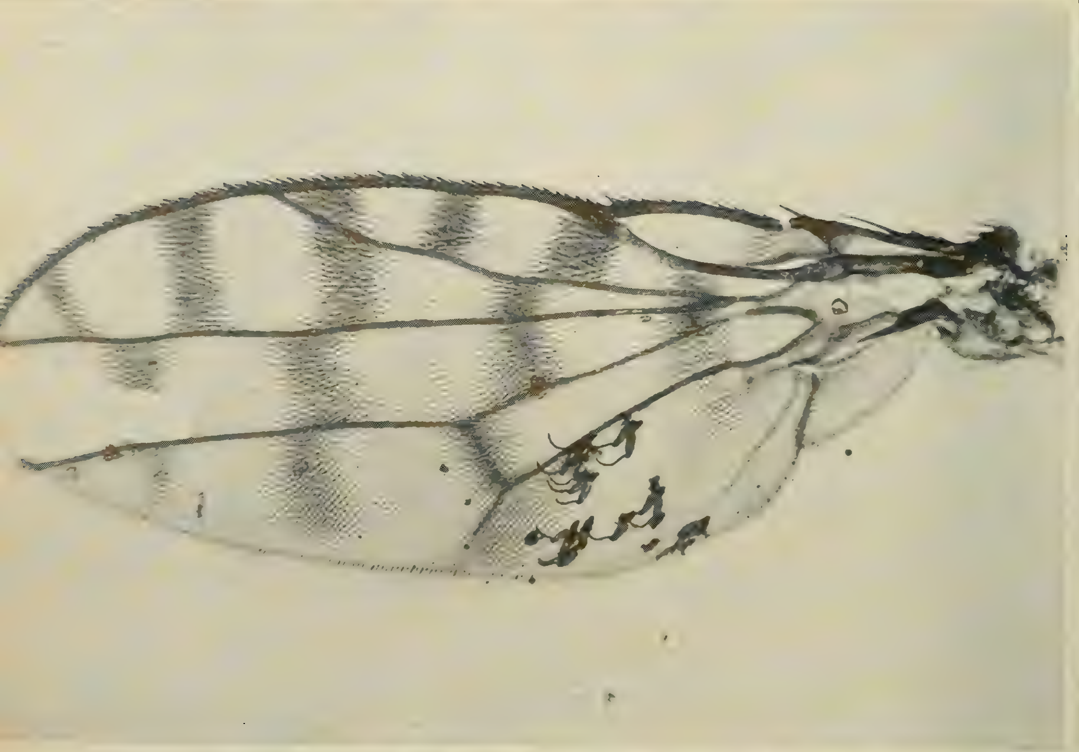
Ascospores leave the female individual (magnified ×350). The "trigger organ" probably aids in discharge of spores.

found in the majority of ascomycetes or in higher fungi in general. In most fungi—even in specialized parasites—the vegetative portion of the thallus typically consists of a mass of interwoven, threadlike filaments (hyphae) called the mycelium. This mycelium usually ramifies more or less extensively throughout the substratum prior to the formation of the more conspicuous spore-bearing structures. In the Laboulbeniales, however, after the ascospore becomes established on the host, the original two cells of the spore undergo divisions that often follow one another so precisely that development of the fungus may be traced cell by cell. This leads to the formation of a cellular body termed the receptacle. The latter varies greatly in complexity from genus to genus. In many genera, such as *Autophagomyces* and *Stigmatomyces*, it consists of only two cells. The lower cell forms the foot that attaches the fungus to the host, and the upper cell gives rise to a lateral, stalked perithecium and a simple terminal appendage consisting of several superimposed cells bearing one or several male sexual organs. In other genera the receptacle may consist of many cells. *Zodiomyces* has a more or less massive receptacle made up of hundreds of cells that form a terminal, cuplike depression within which a large number of reproductive organs and sterile filamentous appendages are produced. On the other hand, the receptacle of *Filariomyces* is an elongate filament consisting of an indefinite number of superimposed cells, several of which bear male or female reproductive structures.

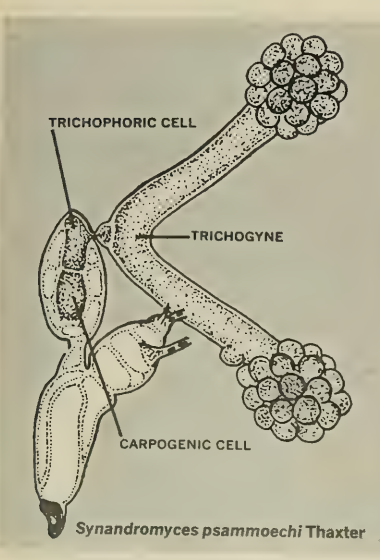
Many, but not all, species of Laboulbeniales exhibit an apparently well-developed sexual mechanism. This involves tiny male cells, called spermatia, that are transferred passively to a receptive structure, the trichogyne, which terminates the female sexual organ. The female organ usually is produced by a cell of the receptacle, whereas the male cells most frequently are formed from certain specialized cells, called antheridia, which are borne on the appendages (*page 46*). However, in a few instances the antheridia, like the female organs, may arise from cells of the receptacle.

The characteristics of the male structures, or antheridia, are currently used to distinguish families within the order. In the Ceratomycetaceae, presumably the most primitive family of Laboulbeniales, the antheridia are simply special cells of the appendages. These form tiny, bacterium-like branchlets that are readily detached and function as spermatia. (Because they arise on the outside of the antheridia, they are said to be exogenous. In contrast, the spermatia of the other two families are termed endogenous because they are formed inside the antheridia.) Antheridia of the Laboulbeniaceae are unicellular and more or less flask-shaped. Each produces a succession of spermatia that are extruded directly to the outside through a single opening. Finally, in the Peyritschiellaceae the antheridia are termed compound because they consist of a cluster of few to many antheridial cells united in such a way that they discharge their spermatia into a common chamber. The spermatia then pass to the outside through a single opening. Many Laboulbeniales have no known male structures, and inclusion of these forms in the above families must be based on other aspects of their morphology. Although the transfer of spermatia to trichogynes has been observed in many species, the actual process of fertilization by means of such cells has not been demonstrated in these fungi.

In all members of the order, so far as is known at present, the mature female sexual structure consists of three parts: a terminal trichogyne (from Gr. *tricho-* = hair + *-gyne* = a female); a median trichophoric cell (from Gr. *tricho-* = hair + *-phorus*

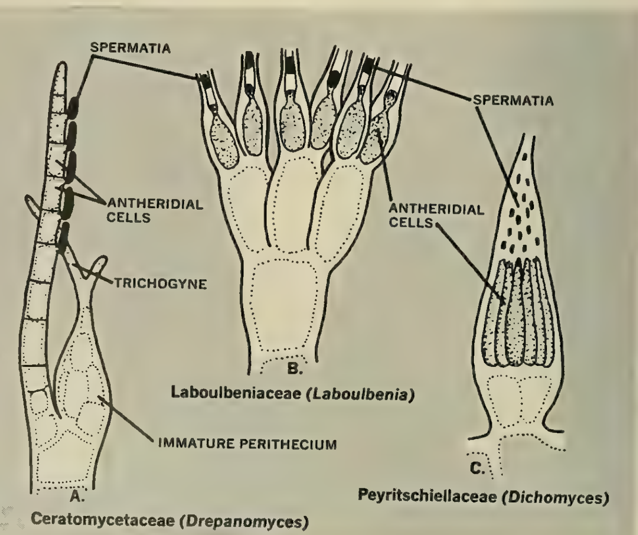


Like species of many genera of Laboulbeniales, that on insect wing, *above*, develops on a definite area of the host. This species is found on left wing of flies of the genus *Ilythea*. A related species occurs only on the right wing.


TRICHOPHORIC CELL
TRICHOGYNE
CARPOGENIC CELL

*Synandromyces psammoechi* Thaxter

Female sexual organ, as represented by one species, has highly developed trichogyne and receptive prominences.


SPERMATIA
ANTHERIDIAL CELLS
TRICHOGYNE
IMMATURE PERITHECIUM
A.
B.
SPERMATIA
ANTHERIDIAL CELLS
C.

Ceratomycetaceae (*Drepanomyces*)

Laboulbeniaceae (*Laboulbenia*)

Peyritschiellaceae (*Dichomyces*)

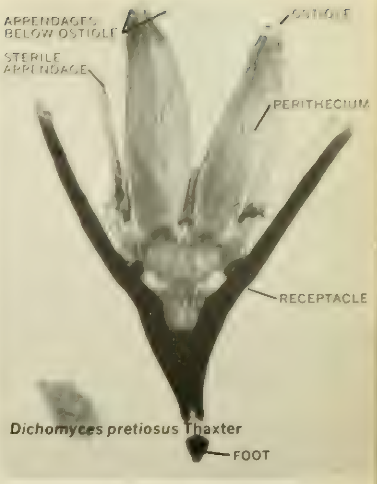
Three male structures bear spermatia (A) on appendage cells; (B) in simple antheridia; (C) in compound antheridia.

= bearing); and a basal carpogenic cell (from Gr. *carpo-* [*carpus*] = fruit + *-genes* = born, produced). The trichogyne may be a single cell or a simple or branched structure composed of several cells. Its function is to intercept the male cells, or spermatia. The trichophoric cell is nothing more than a cell that supports the trichogyne and through which, presumably, the male nucleus migrates on its way from the trichogyne to the carpogenic cell. The latter eventually forms one, two, four, or more ascogenous cells, depending on the species. Each ascogenous cell contains two nuclei, as do the ascus-producing cells of most ascomycetes, and gives rise to a succession of asci by a budding process coupled with conjugate nuclear division.

A mature perithecium in species representing the majority of the genera of Laboulbeniales consists of exactly 37 cells. The elongate portion of the perithecium enclosing the asci is made up of two layers of 16 cells each. In turn, the cells of each layer are disposed in four longitudinal rows of four cells each. The body of the perithecium proper is subtended by five cells. Three circle its base, and the other two are superposed below these. The upper of the latter two cells is termed the secondary stalk cell and the lower is the stalk cell. Stalk cells may be relatively short or greatly elongated. In a few genera there may be five, seven, or an indeterminate number of cells in each row of the inner and outer rows of wall cells. As asci mature, the lower cells of the inner rows of wall cells usually become disorganized and disappear.

In some 16 genera of the order Laboulbeniales all known species are dioecious, or unisexual. In these the male and female sexual structures are borne on separate individuals. Often the individual bearing the male structure is only a little larger than the spore from which it develops. It may consist simply of a few superposed cells terminating in a single antheridium, as in *Dioicomyces* of the family Laboulbeniaceae, or it may be considerably larger and bear numerous antheridia, as in *Dimeromyces* of the family Peyritschiellaceae. There are no known dioecious members among the third family—Ceratomycetaceae. All other genera of Laboulbeniales in which male sexual structures are known usually are bisexual. Both the male and female organs are formed on the same individual; this condition is termed monoecious.

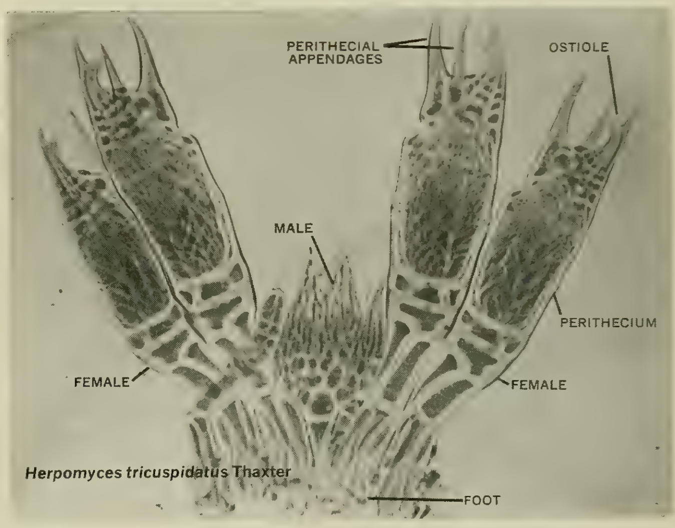
Curiously, only animals belonging to the phylum Arthropoda are known to be parasitized by Laboulbeniales. Most of the described fungus species have been found on the true insects. A few, especially species of *Rickia* and *Dimeromyces*, have been discovered on mites, and a single species, *Troglomyces manfredii*, has been reported on a millipede. Among insects, beetles (Coleoptera) have been most productive of species and genera, but the fungi also have been found on representatives of eight other orders: Blattaria (cockroaches); Dermaptera (earwigs); Diptera (flies); Hemiptera (bugs); Hymenoptera (on ants only); Isoptera (termites): Mallophaga (biting lice); and Orthoptera (on crickets only).



**Rove beetles** are only known hosts of this genus containing about 30 species.

Among obligate parasites, both plant and animal, there usually is a more or less well-developed host specificity. The degree of specificity undoubtedly is a function of the evolutionary age of the parasites in question. That is, the ancestors of those species that exhibit a high degree of host specificity had a long history of close association with their particular host groups. This has led to such marked specialization on the part of many parasites that they may be limited to a single host species or at most to a few closely related ones. The selective processes leading to extreme host specificity also lead to marked tolerance by the host to its parasites. Thus, in highly specialized parasites, such as the Laboulbeniales, the tendency inherent in many less successful parasites to harm the host—that is, to be pathogenic—has all but disappeared.

On the basis of present evidence, it



**Cockroaches** are the hosts for this genus of 25 species, all dioecious. In species above, each perithecium has hornlike appendages below opening.

**Various parts** of worker ant body are parasitized by *Laboulbenia formicarum.*

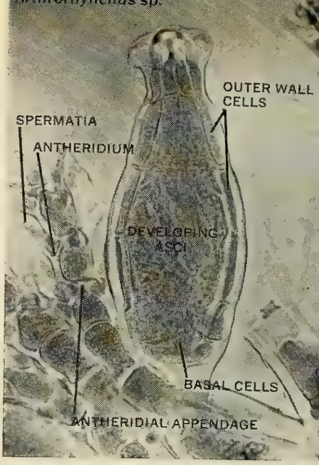
appears that most species of Laboulbeniales are closely restricted to single host species or to closely related species or genera. A few, like *Laboulbenia vulgaris,* may be able to infest a rather wide variety of related hosts, and this species, found throughout the world, has been reported on at least 17 genera representing the tribes Trechini and Bembidiini of the Carabidae (ground beetles). *Laboulbenia cristata,* on the other hand, has an equally wide geographical distribution, but is found only on species of *Paederus,* a genus of rove beetles (Staphylinidae). Some genera, like *Dimeromyces* and *Laboulbenia* with about 85 and 400 described species respectively, have a very wide host range and their representatives have been found not only on mites but on many families in several orders of insects as well.

Other genera have very narrow host ranges. *Coreomyces,* with about 20 species, is found only on members of the Corixidae, the well-known water boatmen, a family of aquatic bugs. *Dichomyces,* a rather large genus of about 30 species, is known only on rove beetles. *Herpomyces,* with 25 species, is found only on cockroaches, but its hosts include nine families of the order Blattaria. Outstanding examples of host specificity within a genus are found in *Ilytheomyces* (15 known species), which is restricted to a single genus of flies, *Ilythea* (family Ephydridae), and *Tettigomyces* (15 described species) known only on mole crickets, *Gryllotalpa* spp.

Insects often are parasitized externally by other animals, and especially by mites. The mites, in turn, can be parasitized by fungi. There are a few known instances in which a single species of Laboulbeniales has been found infesting widely unrelated hosts; in these cases, however, the dissimilar arthropods are intimately associated within their environment. For instance, beetles of the family Passalidae and their mite parasites are known to harbor the same species of *Rickia,* a genus of Laboulbeniales very common on mites associated with this group of insects. *Laboulbenia ecitonis,* one of the few species of the order that occur on Hymenoptera, was found in Brazil growing not only on an ant, *Eciton quadriglume,* but also on two genera of mites that were parasitizing the ant. The fungus also was parasitic on a beetle of the family Histeridae that was living in the ant's nest. These exceptional cases of apparent lack of host specificity may indicate, not an absence of such specificity, but rather the possible evolution of a similar body chemistry in unrelated arthropods, resulting from a long period of intimate association.

A given species of Laboulbeniales may be restricted not only to a single kind of insect but also to a definite location on the host integument. Many examples of such position specificity are known in the order. Both *Ilytheomyces manubriolatus* and *I. lingulatus* may parasitize the same individual host—a species of fly of the genus *Ilythea.* The first grows only on the upper surface of the posterior basal region of the left wing; the second species always occupies a nearly corresponding position on the right wing. A single individual of *Tropisternus lateralis,* a water beetle of the family Hydrophilidae, may be infested with as many as six species of *Ceratomyces,* each of which grows on one certain limited region of the exoskeleton.

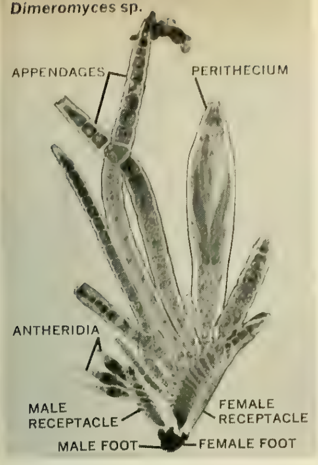
Even more interesting is the phenomenon of sex-of-host specificity, wherein the fungus may be limited not only to a given position on the animal body but also to one or the other sex of insect. Several years ago I had an opportunity to study a large series of specimens of an African water beetle, *Orectogyrus specularis,* which was infected with species of the fungus *Chitonomyces.* Many years earlier Professor Thaxter had described 16 species of this genus, taken from representatives of the same collection of beetles. My preliminary studies indicated that only one of the 16 species was common to both males and females. One hundred specimens of each sex that were heavily infested by this parasite were selected for further study. The identity of each species of fungus and its position of growth on the integument were carefully determined. It was found that of the remaining 15 species, nine were limited to female insects and six to males. There were no exceptions, and the position of growth of each species was so precise that its identity could be predicted in advance by noting its location on the host body!



**Structure** of immature perithecium in this section is at ×500 magnification.

In another study of six species of *Laboulbenia* parasitizing a ground beetle (*Bembidion picipes*), three species were found to be sex specific and three were not. Of the latter, however, one—*Laboulbenia odobena*—grew only on the outer anterior margin of the right elytron (the anterior wing) of females and on the lower distal surface of the femur of the right anterior leg of males.

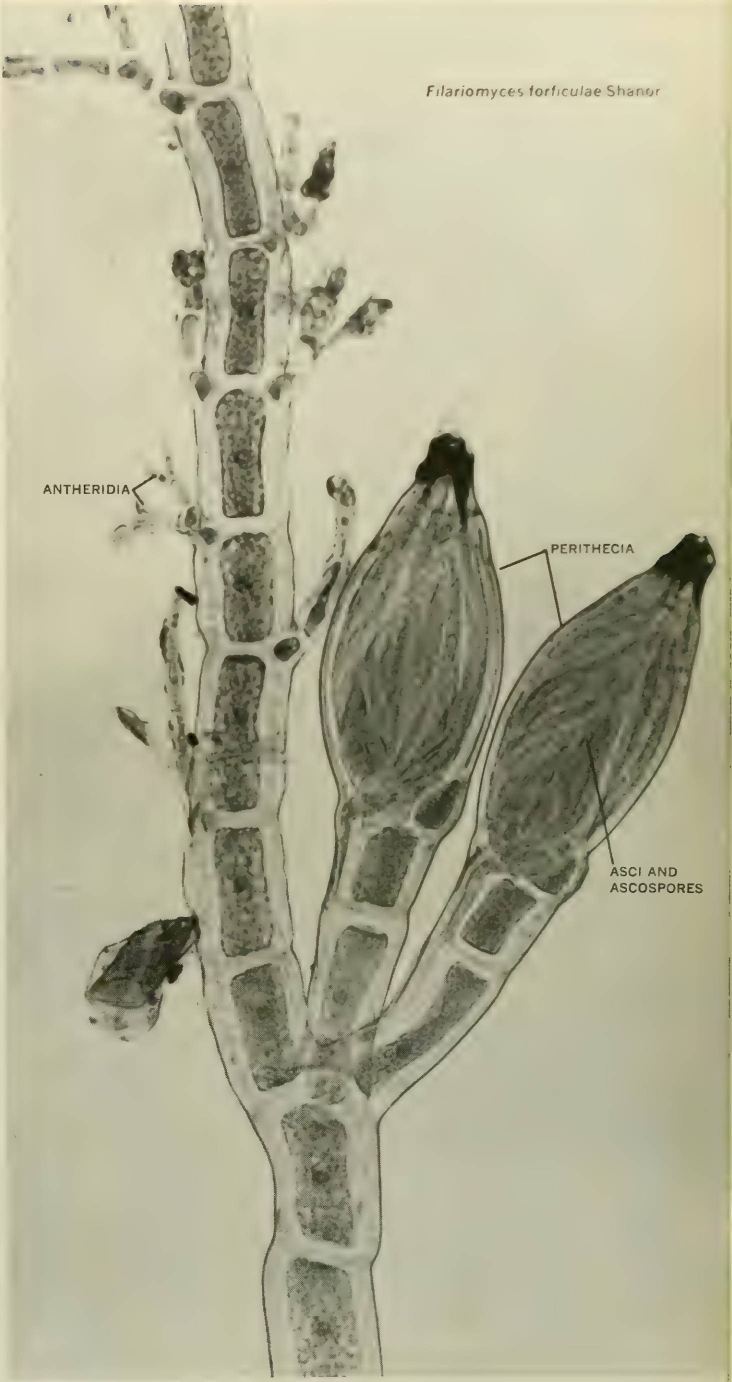
Experimental studies offering explanations of the above specificity phenomena still are needed. In the case of *Laboulbenia odobena* on *Bembidion picipes,* location of the parasite appears to be correlated with the position assumed by the insects at the time of mating. Many species of Laboulbeniales probably are found on particular parts of the host integument as a result of direct transmission associated with certain behavior patterns of the insects involved. Among a number of the species that usually exhibit rather marked position specificity, it is not uncommon to find isolated individuals—normal in all aspects of



UNNAMED SPECIES of *Dimeromyces* has separate male and female individuals.

their morphology—growing randomly on their hosts. Specificity of other species undoubtedly is correlated with histochemical differences of the insect body. *Herpomyces stylopygae* normally matures only on the antennae and less commonly on the mouthparts of its cockroach host, *Blatta orientalis.* Spores of this species often are deposited abundantly on other parts of the insect's body, but they rarely develop.

The Laboulbeniales offer many challenges to the biologist. Although a great many species and genera have been described, most of those actually existing probably are yet unknown. Relatively few of the nearly three-fourths of a million described species of insects have been examined for these parasites, and it has been estimated that only one-fifth—perhaps only one-tenth—of the insects actually living on earth have been discovered. Detailed developmental studies have been made on only a few of the known species of these fungi. Comparative morphological studies are essential to a better understanding of the possible interrelationships of organisms such as these for which a fossil record is lacking. Closely related insects often have closely related parasites. Thus, knowledge of the host range of the Laboulbeniales may, in the future, provide an aid in elucidating problems of insect interrelationships. Finally, the various types of specificity encountered in the Laboulbeniales should present numerous challenges to students of insect behavior as well as to the many physiologists and biochemists who are increasingly interested in the reasons underlying such phenomena.

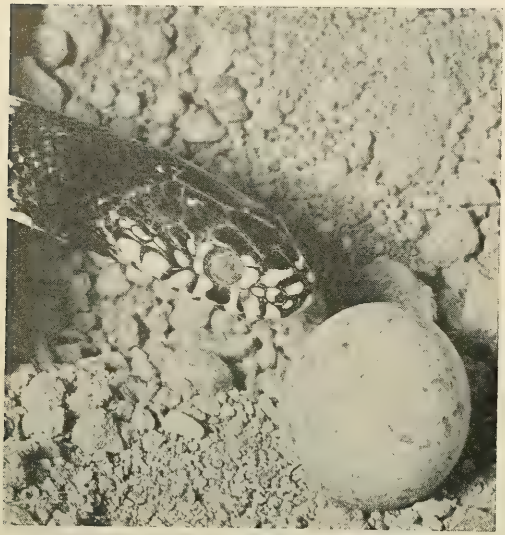


SIMPLE, filamentous receptacle has many superposed cells bearing stalked perithecia and antheridial appendages. Species parasitizes one of the earwigs.

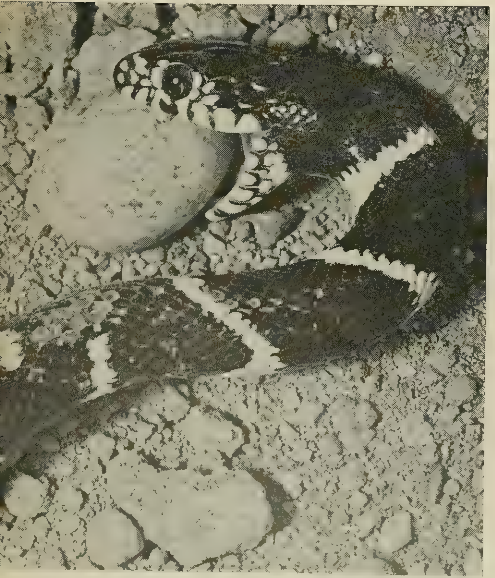
# A King Snake Dines on a

Photographs by Robert H. Wright

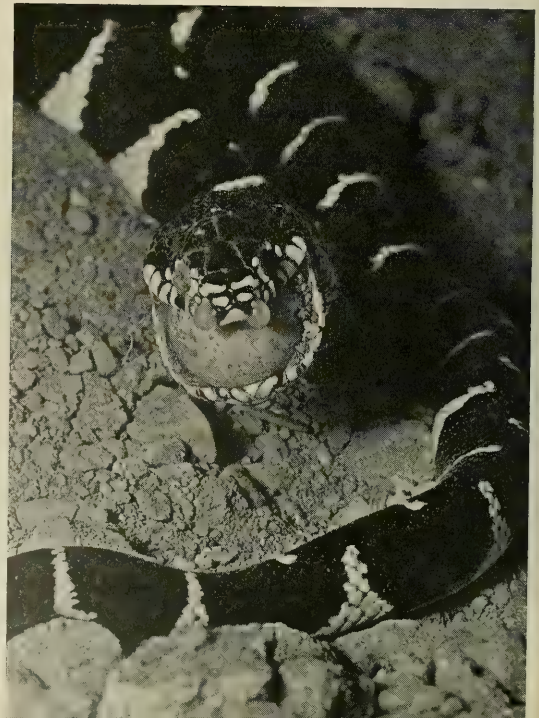
THE small California king snake (*Lampropeltis getulus*), shown on these pages devouring a sparrow egg, demonstrates the ability of many snakes to swallow objects that are substantially larger than the reptiles' heads. This ability depends, in turn, upon the snake's capacity to distend the mouth opening, but it is not essentially a matter of the snake being able to open its mouth inordinately wide. Rather, as shown by the photograph directly below, the lower jaw is primarily responsible for increasing the size of the mouth opening. The two halves of the jaw are not firmly joined in front. Instead, the bones are connected by an elastic ligament that allows lateral expansion of the lower jaw. Once a snake secures a large object in its mouth, small, movable bones in the upper jaw aid in drawing it into the digestive tract. A snake can swallow an egg without breaking it. Here—perhaps because the snake could not use the sides of a nest to help it secure the egg—the teeth in the roof of its mouth punctured the egg, allowing its contents to flow through the snake's nostrils. Depending upon the temperature and the amount of yolk it ingests, the snake may take hours or even days to digest a meal.



*Exploring the egg, above, snake flicked it with tongue for several minutes. The cloudy eye indicates partial blindness.*



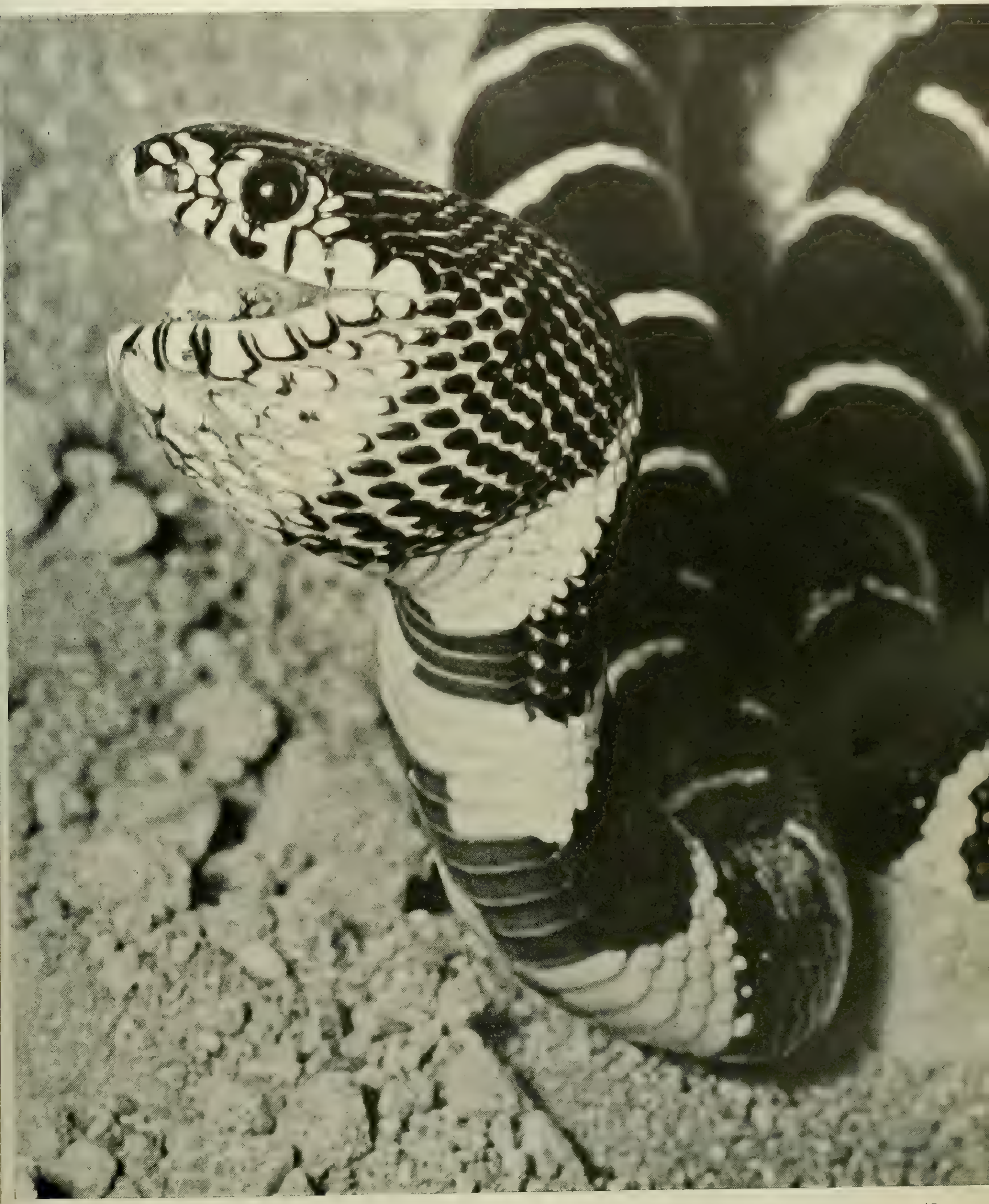
*Its lower jaw employed as a scoop, above, snake holds egg with its teeth to compensate for lack of support.*



*Head-on view, at right, shows flexibility of lower jaw, bones of which are joined in front by elastic ligament.*

# Sparrow Egg

*When shell was punctured, egg's contents flowed through nostrils. It took snake twelve minutes to swallow egg.*



# Spread of a Parasite

## Dwarfmistletoe fruits are effective propellants in seed dispersal

By Frank C. Hawksworth
and Thomas E. Hinds

Dwarfmistletoes, members of the mistletoe family Loranthaceae, are small, innocent-appearing plants that are actually among the most serious forest enemies in the West. They are parasites that take root in coniferous trees only—pine, spruce, true fir, Douglas fir, hemlock, and larch—and kill more trees than any other disease in western coniferous forests. They also cause considerable loss of valuable timber through reduced growth rates of infected trees. A forest pathologist with the U.S. Forest Service recently estimated that the loss caused by these parasitic plants in the western United States is about one billion board feet annually. This is enough wood to build 100,000 average homes.

Each species of dwarfmistletoe is restricted to a particular host tree or group of closely related hosts. It may occasionally grow on other species of trees, but so infrequently that it does a negligible amount of damage. The dwarfmistletoe is leafless, and therefore depends on its host for elaborated foods (carbohydrates, sugars, enzymes, vitamins, etc.), as well as for water and minerals. Most of the host's infected branches develop abnormally into "witches'-brooms," which are growths of unusual branching habit, often with dense foliage, that appropriate food materials at the expense of the rest of the tree. Infected branches may become several times larger than uninfected branches, and they tend to persist long after uninfected branches are shaded out. The vigor of the tree's crown then declines, and premature death follows.

The family Loranthaceae contains some 40 genera and 1,300 species, all parasitic to some degree, and is most widely distributed in the tropics. Dwarfmistletoes (*Arceuthobium*), and leafy or Christmas mistletoes (*Phoradendron*) are the two genera of the family that occur in the United States. Leafy mistletoes differ from dwarfmistletoes in that they attack hardwood trees principally, although several western species attack juniper and cypress. Another major difference is the dwarfmistletoe's explosive seed-dispersal mechanism. Leafy mistletoes depend on birds for spreading seeds.

About a dozen species of dwarfmistletoes are widespread in western North America from Guatemala to Alaska. One species occurs on spruce in the eastern United States and Canada from the Great Lakes to the Atlantic, and a few others are scattered throughout the Northern Hemisphere in the Old World. Most species have shoots only three or four inches high, and, when growing on tall trees, they are not easily seen from the ground. The shoots are variable in color, as are the flowers and fruits: some are green, while others are orange, reddish, brown, or even black.

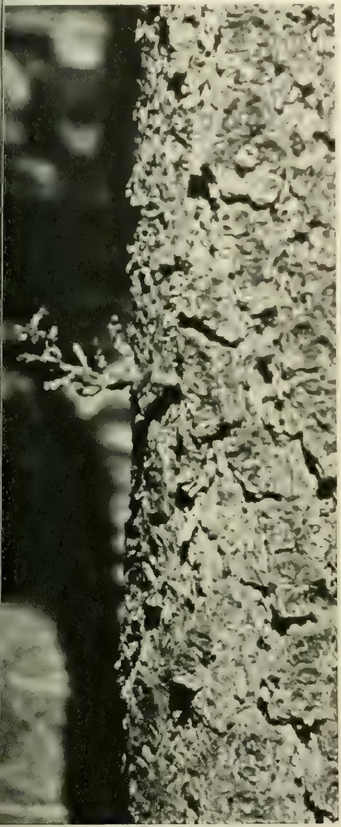
As is often the case with parasitic organisms, the most specialized dwarfmistletoes are those limited to particular hosts. One highly specialized western species, for instance, usually attacks only Douglas fir and is less than one inch high. At the other extreme, some of Mexico's "giant" dwarfmistletoes, with shoots nearly two feet high and over one inch in diameter, have correspondingly wide host appetites. They grow with seemingly equal facility on at least eleven species of pine.

A remarkable aspect of the dwarfmistletoe is its seed-dispersal mechanism. A number of plants have explo-

WARFMISTLETOE PLANT, *left*, infects branch of ponderosa pine in Arizona.

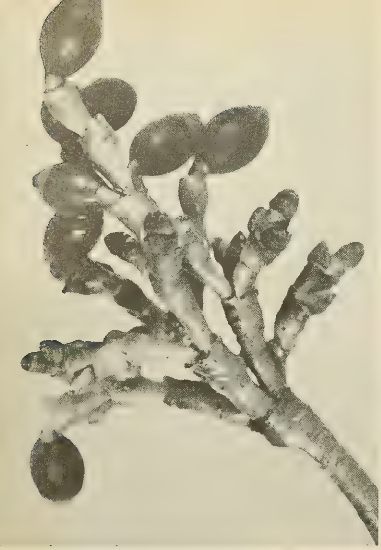
ABNORMAL BRANCHES, *right*, caused by parasite, are called witches'-brooms.

SHOOTS emerge from tree's bark after a two- to five-year incubation period.



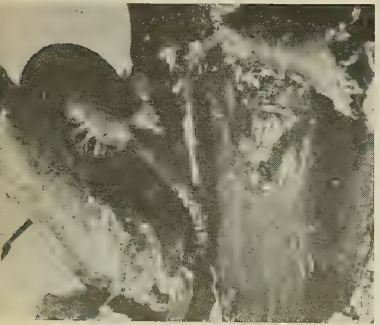
sive fruits—witch hazel, castor bean, and a few species of *Viola* (violets) and *Phlox*, for example—but the dwarfmistletoes' method of seed dispersal is one of the most efficient in the whole plant kingdom. The process is not exactly understood, but certain aspects of the mechanism can be described. Each fruit contains a single, tear-shaped seed 2 to 3 mm. long and weighing about 2 mg. As the fruit begins to approach maturity, its stem is elongated and recurved so that the original apex of the fruit points downward. (*See diagram, page 55.*) An abscission zone then develops between the tip of the stem and the base of the fruit, and a layer of cells between the seed and the fruit's hull absorbs water and creates a high internal pressure. (This zone for separation is similar to the abscission zone at the bases of leaves in other plants facilitating leaf fall in the autumn.) Finally, the fruit falls from the stem, the hull contracts rapidly, and the seed is squeezed out and hurled upward. Its round forward end and a pointed base make the seed a most efficient projectile.

To learn more of how dwarfmistletoes spread through the forest, we conducted studies on the ballistics of seed flight by use of high-speed photography. We calculated that the seed's initial velocity as it leaves the fruit is 80 to 90 feet per second, or about 60 miles per hour! Of all the methods of explosive seed dispersal in plants, the dwarfmistletoes have evolved one of the very few that controls the vertical angle of seed discharge. Most other plants with explosive fruits do not have this control because they expel their seeds after the fruits are shed. We used a cotton-lined apparatus (*page 55*) to measure the discharge angle of several hundred dwarfmistletoe seeds and found it to average 30 to

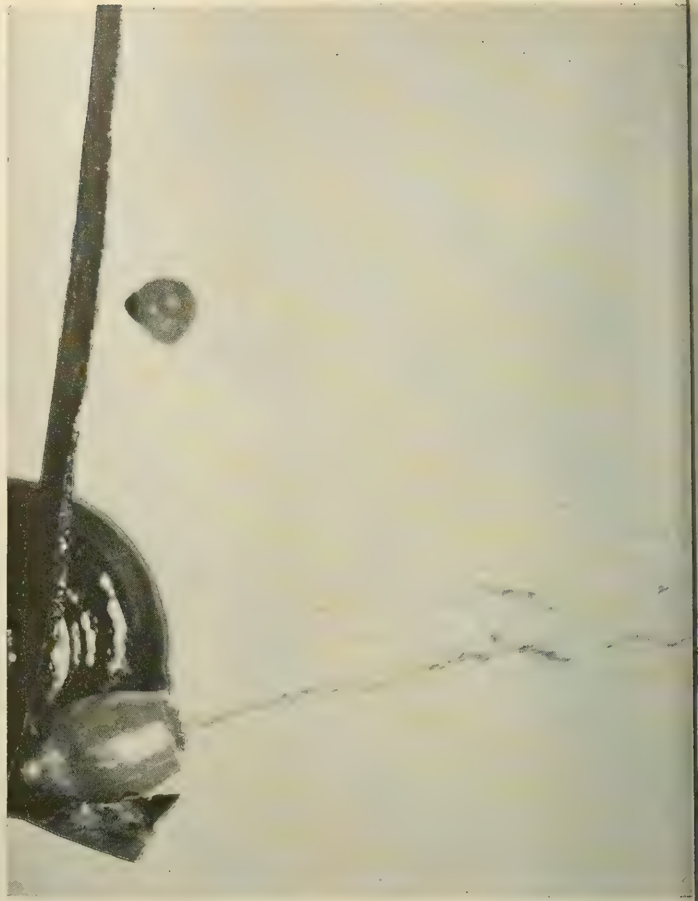


Large fruits, measuring 3×5 mm., near the end of a 16- to 18-month maturation.

Single shoots live from one to five years, and new ones continue to emerge.



Rootlet of a seed that has been in place two months germinates on twig.

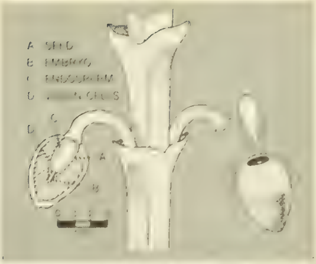


40 degrees above the horizontal. This approaches the 45-degree angle that, experts have found, gives the maximum horizontal distance with a mortar.

Dwarfmistletoe seeds may travel horizontally for 50 feet, but the average distance is 10 to 15 feet. Seeds expelled high in the trees on windy days may go somewhat farther, usually spreading the greatest distance in the direction of prevailing winds. Dr. J. R. Wier, a pioneer forest pathologist in the northwest and one of the first to recognize the importance of dwarfmistletoes, recorded an extreme case in which dwarfmistletoe seeds from an infected larch had been blown by high winds to the roof of a cabin nearly a quarter of a mile away.

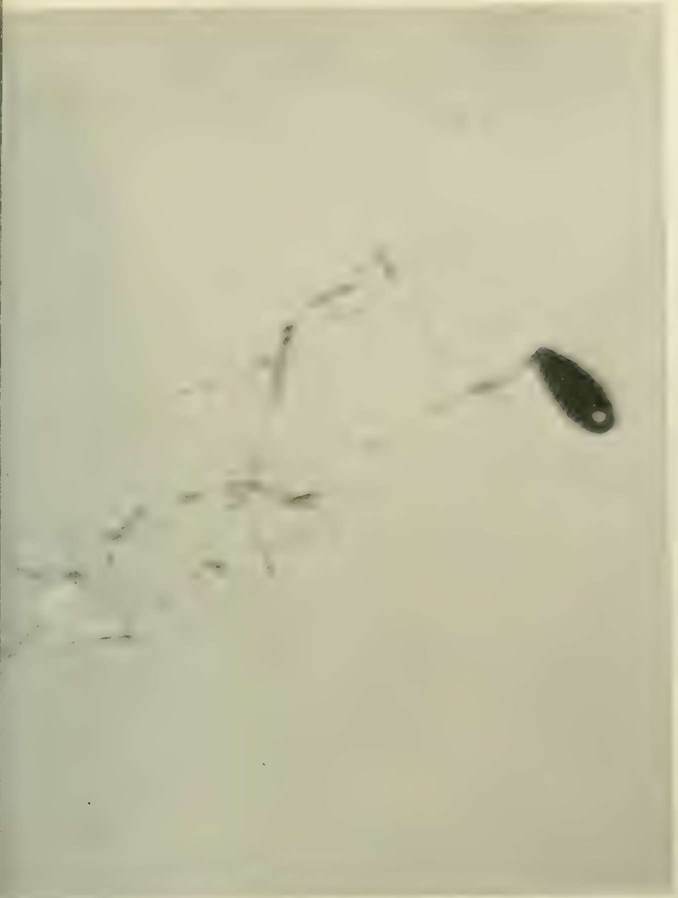
Seeds are scattered about in all directions from infected trees. They land everywhere—on various parts of trees, on understory vegetation, and on the ground. Fewer than half of the seeds produced lodge on trees, and fewer than 5 per cent of those actually take root. The ones that do result in infection, however, are usually those that land on the needles. A viscous, adhesive coating enables them to stick where they land. When moistened by rains, this coating lubricates the seeds so they can slide down to the twigs.

GERMINATION must occur at or near young twigs to produce infection on the host. Many seeds, of course, fall from the needles and are lost, but enough slide down to the twigs to maintain parasitic populations. Once on the twig the seed germinates, and its radicle (rootlet) penetrates the bark of the twig. The young dwarfmistletoe plant then undergoes a



**As mature fruit** falls from stem at right, viscin cells force seed upward.

**Plant**, center, expels seeds into cotton, and the discharge angles are measured.

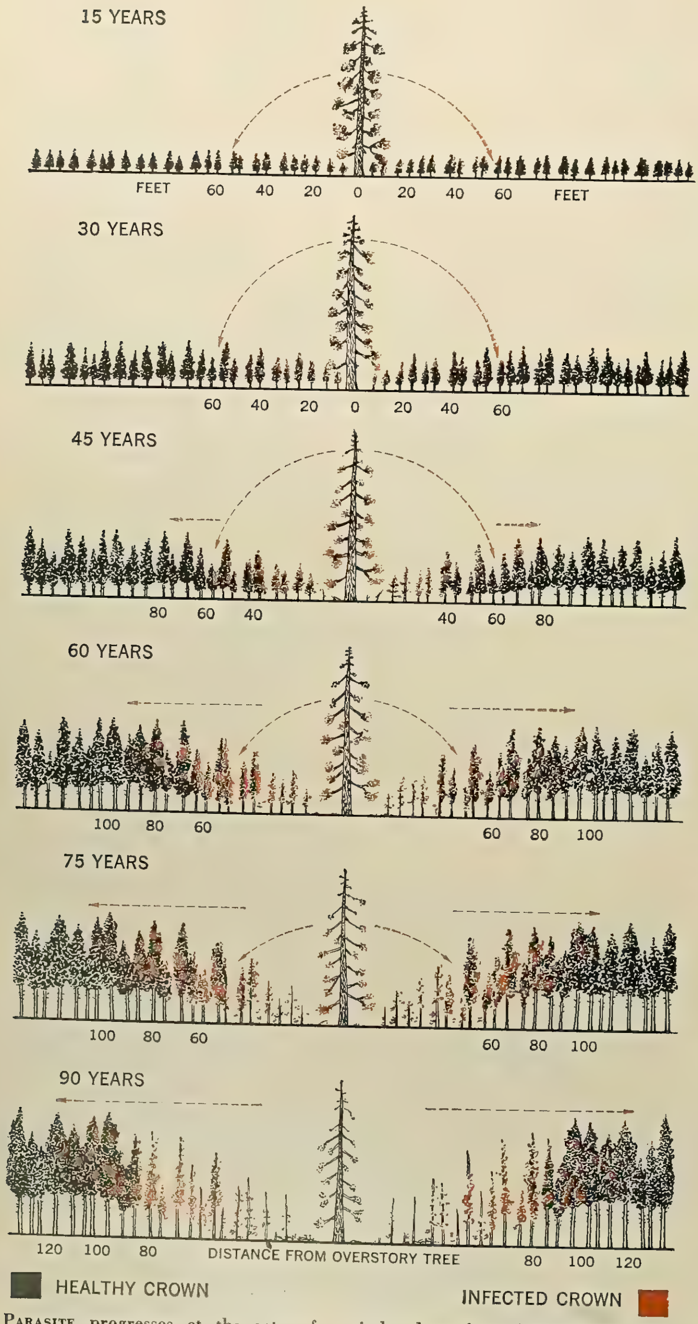


**Photograph**, taken at five millionths of a second, shows dwarfmistletoe seed after expulsion. Note trail of liquid.

two- to five-year incubation period within the host twig before shoots emerge from the bark. Flowering begins one to two years later, when the shoots are $1\frac{1}{2}$ to 2 inches long, depending on the species, and the first seeds are produced about one year after that. Individual shoots are relatively short-lived (from one to five years or so), but new shoots continually emerge from the perennial root system within the host twigs.

Control of the dwarfmistletoes is a requisite for adequate tree growth in many areas in the West. Fortunately, these parasites can, in many cases, be controlled with only slight modifications of current timber-cutting practices. The basic idea behind control is to break the chain of infection to protect young trees of subsequent generations. If only the trees

**Leafless** dwarfmistletoes grow on a ponderosa pine branch. An individual tree may bear several hundred plants that depend on the host for nutriment.


15 YEARS
FEET
60
40
20
0
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FEET
30 YEARS
60
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45 YEARS
80
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80
60 YEARS
100
80
60
60
80
100
75 YEARS
100
80
60
60
80
100
90 YEARS
120
100
80
DISTANCE FROM OVERSTORY TREE
80
100
120
HEALTHY CROWN
INFECTED CROWN

SPREAD OF INFECTION IN PONDEROSA PINE

**Parasite** progresses at the rate of ten to fifteen feet per decade, causing timber loss of one billion board feet annually in the western United States.

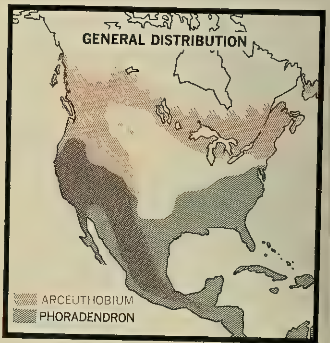
large enough to be sold are cut, small deformed trees are left to spread the infection. Control is accomplished either by felling or pruning all infected residual trees, including those that are too small to be utilized commercially.

The spread of the dwarfmistletoe through a stand is relatively slow and localized—despite its efficient seed-dispersal mechanism—compared with the spread rate of most forest tree diseases. The parasites usually progress at a rate of about 10 to 15 feet per decade, in contrast to the spores of fungus-caused diseases that may be wind borne for hundreds of miles. Thus an area will, for all practical purposes, remain healthy for a long time after the dwarfmistletoe is eliminated.

Other methods of controlling the dwarfmistletoes, such as the use of chemicals or biological agents, remain in the experimental stage. Chemicals, when they become available, will be particularly applicable in places where it is desired to save individual trees, such as in recreation or other high-value areas. There is less need for chemical treatment in a forest managed chiefly for timber production. In most instances, the parasite there can be controlled by logging practices.

In addition, the possibility of biological control of the dwarfmistletoe by use of fungi or insects is currently under investigation at laboratories in California, Idaho, and Colorado. Several insects that feed on the dwarfmistletoes (particularly the spittlebug) and a few fungi that attack them have been discovered, but their potential as dependable biological control agents still remains to be determined.

**Infected** lodgepole pines in Colorad
display witches'-brooms and dead top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AVIANCA, The Colombian Airline, has coordinated a tour based on the recent and well received book, THE BIRDS OF COLOMBIA. The author, Mr. R. Meyer de Schauensee, is Curator of Ornithology at the Academy of Natural Sciences of Philadelphia, and is acting as Scientific Consultant to the tour.

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## About the Authors

Dr. Robert M. Netting, Assistant Professor of Anthropology at the University of Pennsylvania, wrote "Heritage of Survival." Dr. Netting conducted field research in Nigeria from 1960 to 1962 with the aid of a Ford Foundation Fellowship and received his Ph.D. from the University of Chicago in 1963, writing his thesis on Kofyar agriculture. He is particularly interested in the problems of cultural ecology—the interrelations of man and his environment.

"Day Length and Food Caches" was written by Illar Muul who is a research assistant at the Museum of Zoology, University of Michigan. The article is based on part of Mr. Muul's doctoral study of how climate affects the behavior and distribution of the flying squirrel. His research was financed by a grant from the National Science Foundation.

Dr. Winton Patnode, a scientific research consultant who lives in Eugene, Oregon, collected and photographed the algae described in "Green Algae Divide to Multiply." Dr. Patnode was an industrial research chemist for many years and is now a specialist in photomicrography. He has combined his skill as a photomicrographer with his interest in botany to make handsome photographs of plant cells and tissues as they are seen through the microscope.

Dr. Thomas Eisner, co-author of the article on millipedes, is an Associate Professor of Biology at Cornell University, who is currently on sabbatical leave doing research at the Landbouwhogeschool Entomology Laboratory in the Netherlands. His father and co-author, Dr. H. E. Eisner, is a retired chemist who now works in his son's research laboratory. Dr. Thomas Eisner wrote an article on the defense mechanisms of the whip scorpion, or vinegaroon, for Natural History in June, 1962.

"Study in Specificity," discussing the parasitic fungi Laboulbeniales, was writen by Dr. Richard K. Benjamin who is a mycologist at the Rancho Santa Ana Botanic Garden in Claremont, California. Dr. Benjamin did his undergraduate and graduate work in botany at the University of Illinois and was a National Research Fellow at Harvard University, 1961-62, where he had the opportunity to study the Thaxter collections of Laboulbeniales. He is President of the Mycological Society of America.

Dr. Frank G. Hawksworth and Thomas E. Hinds, authors of "Spread of a Parasite," are forest pathologists with the U.S. Forest Service, stationed at the Rocky Mountain Forest and Range Experiment Station, Colorado State University. For the last fifteen years, they have done research on the biology and control of dwarfmistletoes in the Central Rocky Mountains and the Southwest.

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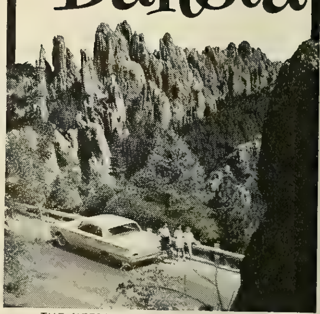

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# nature and photography

## a second camera may prove valuable

### by David Linton

One of the advantages of owning a high-quality camera of any well-known make is the wide range of accessories available, enabling one to do almost any type of photography. A variety of lenses can be used with a good camera, and adapters will allow the use of other lenses not designed for that particular piece of equipment. One can buy telescope adapters and microscope adapters, watertight housings for using the camera under water, and close-up attachments for working at closer distances than those at which the camera normally focuses. For the rangefinder type of 35 mm. cameras there are reflex focusing devices that make them operate like single-lens reflex types. For some cameras there are bulk film magazines to increase the number of pictures that can be taken before reloading, and motor drives to advance the film and wind the shutter when the camera is unattended. In at least one line there is even a radio-operated remote-control mechanism that will control the camera from a point several miles away.

The more elaborate accessories may cost as much as the camera itself. Without doubt they are tempting pieces of hardware, but buying one may not be the best way to solve a photographic problem. For a specific, limited purpose it is often better to buy an inexpensive second camera than to adapt a versatile, expensive camera for a special use.

### The Camera Trap

A case in point would be a camera trap—a device by which animals take their own pictures by tripping an unattended camera, usually set up at a water hole or feeding station. The rapidity and convenience of operation that distinguish expensive cameras are clearly of no use in such a setup. A fast lens is seldom an advantage because the exact spot where

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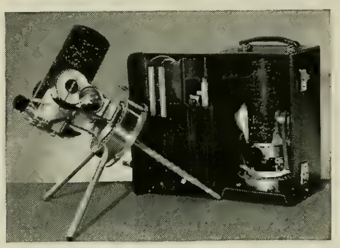
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the subject will be cannot usually be predicted. The lens must ordinarily be stopped down to insure that the subject will be in focus. Obviously, the rangefinder, reflex, or ground-glass focusing system is of no utility if there is no one operating the camera; the initial focusing when the camera is positioned can be done with a tape measure. The one feature that is really valuable in a camera for trap use is a motor drive, but this is expensive and available for only a few types of cameras.

Unless it has a motor, a "good" camera is wasted in a camera trap because its expensive features cannot be used. There is, of course, no harm in that, but there is a danger that the camera will be damaged, and it is silly to expose a good camera when, in this particular case, a cheap one will do the job just as well. There is always a possibility that some animal—not necessarily the intended subject—will decide to investigate the sturdiness and edibility of the camera. Porcupines are inordinately fond of anything that has a salty taste, including leather straps and the synthetic rubber insulation of wires. Raccoons are not so likely to chew photographic equipment, but they are extremely curious, and are dexterous enough to untie knots. Even if the animals leave the camera alone, it is still exposed to the weather and possibly to the depredations of humans. Wrapping the camera in plastic sheeting is not a very reliable way of protecting it from the rain; dampness will penetrate anyway, and an opening must be provided for the lens.

**David Linton**'s by-line has appeared under photographs in all the nation's leading magazines. His camera column is a regular feature on these pages.

## Flora at Close Range

Suppose that your good camera is a rangefinder type and you propose to take a series of pictures of individual wildflowers: this will require shooting at such close range that the rangefinder cannot be used. You will need some sort of close-up adapter and you must either focus by tape measure or equip the camera with a reflex focusing scope. A fast lens is quite unnecessary, because at a wide opening it would not give sufficient depth of field to get all of the subject in focus. For this type of work there is a simple camera—essentially a box camera, as the focus is fixed—especially designed for taking close-ups. It was made originally for dental work. A rectangular wire frame is mounted on rod that project from the front of th camera. The whole camera is moved i until the subject is in the frame; th subject will then be in focus and centered on the film. The camera is designed to be used with flashbulbs, but any othe light source (including natural light) o sufficient intensity will do. The lighting produced by the flashbulb in its norma position on the camera is adequate bu unattractive. It can be improved by moving the flash away from the lens and using a reflector to throw some light into the shadows. (The problems of lighting close-ups were discussed in "Nature and the Camera," February, 1962.)

## Photomicrography

To take another example, suppose you are to take a series of photographs through a microscope: the simple technique described in this column in May, 1964, can be used with almost any camera, but if there are a number of photomicrographs to be made it would be better and more convenient to get an inexpensive second camera. It would not need a lens, because the microscope lenses form the image. Many people forget that most cameras on which the lenses are removable can be bought without a lens, and that the lens is the

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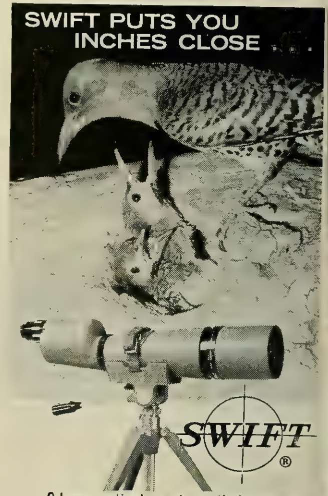

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most expensive part of a camera. A small camera with a simple shutter will be just as useful for microscope work as a camera with an elaborate shutter that has more and higher speeds. The high shutter speeds can seldom be used with a microscope, in any case; short exposures are produced by using short, intense flashes of light. Actually, a camera intended exclusively for microscope work would not even need to have a shutter, since the exposure is usually controlled by turning the light source on and off to avoid the vibration produced by a mechanical shutter. A camera to be used in photomicrography does need a convenient viewing system. The best choice is probably a simple single-lens reflex camera that has an adapter to couple it to the microscope. The cost of such a camera (without lens) may be considerably less than that of the adapter required for a range-finder camera.

### The Camera Under Water

PICTURE taking under water is another example where a second camera may be indicated. Underwater housings are available for almost any good camera, but only the more expensive models have controls for changing the focus, and very few permit the photographer to see when the subject is in focus. (It is impossible to see through most viewfinders if you are wearing a face mask.) There is always a chance that the housing will spring a leak, and there is a greater danger that the camera will get wet when the housing is opened to change the camera settings or to reload. Salty spray and damp fingers are not good for fine optical equipment.

Instead of risking damage to an expensive camera, it may be more convenient, safer, and less expensive to use a submersible camera. The simplest one is a plastic box camera designed for underwater use. It sells for about twenty dollars and has no controls except a film winder, but you can use different kinds of film in brighter or darker waters. If it does leak, you can simply rinse it out with fresh water, dry it with a towel, put in a new roll of film, and start shooting again. There is also a higher quality submersible camera on which the focus, shutter speed, and aperture can be changed under water. While it has no visual focusing system, it does have an interchangeable 35 mm. lens.

There will be, of course, other photographic situations in which an inexpensive second camera may be a wiser choice than an accessory: what these situations have in common is that the expensive features and ease of operation that account for the high price of a good camera are of no real advantage. In any such case, the use of an extra camera should be seriously considered.

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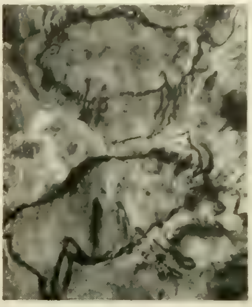

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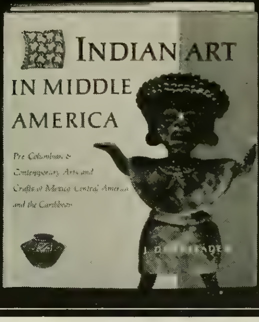
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# Hoaxes and half-truths

**By Robert Silverberg**

THE literature of scientific hoaxing is rich and varied, encompassing the explosive Piltdown Man fraud, which was exposed little more than a decade ago; Dr. Cook's controversial claim to the discovery of the North Pole; the monumental "Etruscan" statues that proved so embarrassing to The Metropolitan Museum of Art in recent years; and many others. Men of seeming rectitude have done their best to confuse, to deceive, and to obfuscate. The psychopathology of hoaxing is a fascinating study in itself, worthy of investigation. Here we can deal only with two hoaxes that had broad repercussions.

## The Kammerer Affair

THE shot that ended Paul Kammerer's life in 1926 closed the books on one of the most tragic of scientific hoaxes. Kammerer, a brilliant young Austrian biologist who had been hailed as "the modern Darwin" by one enthusiastic Cambridge zoologist, was a neo-Lamarckian who sought to prove the inheritance of acquired characteristics. This philosophically minded scientist tended to approach his work with the results already assumed, always a dubious practice in the laboratory: "If acquired characteristics cannot be passed on . . . then no true organic progress is possible," he wrote in his celebrated book, *The Inheritance of Acquired Characteristics*, published in 1924. "Man lives and suffers in vain. Whatever he might have acquired in the course of a lifetime dies with him."

Kammerer carried on research at the Institute for Experimental Biology of the University of Vienna, studying toads, salamanders, and other amphibians for twenty-three years, searching for the proof that would confute Darwin.

His first experimental subject was the olm (*Proteus anguinus*), a large European cave salamander with vestigial eyes that are visible in the larvae but hidden in the adult. Like most cave-dwellers, olms are pale in color. Kammerer discovered that the animals tended to darken when exposed to light and, having darkened his olms in an illuminated aquarium, he returned them to a lightless environment where they mated and produced dark-skinned offspring. It seemed clear proof of the inheritance of acquired characteristics, but Darwinian-minded colleagues did not agree. The renowned biologist and hereditist August Weismann observed that the skin of the olm is translucent. Light passing through the skin in the course of Kammerer's experiments might well have reached the gametic cells, inducing a dark-skinned mutation. So Kammerer's results could be explained in terms of orthodox genetic theory, rather than of inheritance of acquired characteristics.

Unable to answer Weismann's objections satisfactorily, Kammerer turned to other experimental animals. He first selected the fire salamander (*Salamandra salamandra*), a plump creature four or five inches long, deep black in color, with large, glossy yellow spots. Kammerer postulated that the fire salamander would tend to change its color to make itself less conspicuous against the background of its environment, and that color change would be inheritable.

He raised one group of fire salamanders in a terrarium whose topsoil was black and another on yellowish soil. Gradually, so he reported, the salamanders raised on black soil were losing their yellow spots. In the other terrarium, each generation of salamanders had larger yellow spots than its predecessor, so that eventually, Kammerer then postulated, there would be only all-yellow and all-black fire salamanders in the laboratory. Other biologists were baffled and distressed by Kammerer's results, which ran counter to established genetic belief. Such changes, in the absence of predators, could scarcely be attributed to selection. Yet so great was the prestige of the Institute for Experimental Biology, and that of Kammerer himself, that his statements were received seriously.

## Disappearing Spots

THE biologist's achievements with the midwife toad (*Alytes obstetricans*) were even more spectacular. The mating of many toads takes place in water. During the mating season, pads on the males' inner toes become black and swollen. These nuptial pads supposedly assist the male in maintaining its grip on the female.

The midwife toad mates on land, however, and has no nuptial pads. Kammerer built a terrarium designed to persuade midwife toads to mate in water. According to Kammerer, the offspring of these toads also preferred to mate in water, and he declared that at least one male offspring exhibited nuptial pads.

Reputable scientists were awed by Kammerer's reported results, but the majority were skeptical.

Five years had elapsed between Kammerer's first announcement of his experimental findings on the salamanders and midwife toads and the appearance of *The Inheritance of Acquired Characteristics.* During this time, he had refused to allow other scientists to examine his specimens. Not until 1926, after steady prodding, did Kammerer yield; Dr. G. Kingsley Noble of The American Museum of Natural History and Dr. Hans Przibram of the University of Vienna, director of the institute where Kammerer had done his research, were allowed to inspect the famous amphibians. Soon after, on August 7, 1926, a pair of independent reports—one by Noble and one by Przibram—appeared in the English scientific publication, *Nature.* They agreed that Kammerer's results were fraudulent. Noble had examined the so-called nuptial pads of the midwife toad and had found they lacked the epidermal spines that should have been present. In his report he noted, "The left wrist of the specimen had been lacerated. A slight pushing aside of the muscles revealed that the ventral wrist muscles and part of the palmar muscles were surrounded by a black coloring matter on all sides. This substance was in such abundance that it readily washed out in the dissecting dish water which filled the spaces between the exposed muscles." The black spots marking the pads were, in fact, nothing but spots of India ink that had been injected into the forefeet of the preserved midwife toad.

## An Unanswered Question

Confronted with this exposé, Kammerer insisted that someone must have tampered with his specimens. Only two other men held keys to Kammerer's laboratory. One was Dr. Przibram, a close friend; the other was a biologist named Megusar, who had disliked Kammerer and often had quarreled with him. Had Megusar altered the specimens? There was no answer; Megusar had died several months before.

On September 22, 1926, Kammerer wrote a long, rambling letter to the Moscow Academy of Science, which had supported his findings. "I found the statements of Dr. Noble completely verified," he admitted, revealing that his "black" salamanders were also frauds since they had had their yellow spots covered by ink. "There is no doubt," Kammerer said, that "almost my whole life work has become dubious. . . . I did not participate in this fraud. . . . Moreover, I find it is impossible to survive the destruction of my life work. I hope to find tomorrow sufficient courage and fortitude to end my wretched life."

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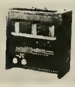

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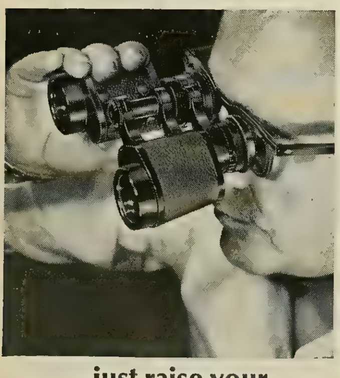

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Kammerer found that courage the next day. His suicide was a severe blow to neo-Lamarckian biologists. In Russia, then favorable to Lamarckian theories, Kammerer was regarded as a martyr of science, victimized by scheming enemies. The Russians went so far as to produce a melodramatic motion picture about the case, exonerating Kammerer completely and depicting a villainous bishop and a wealthy German nobleman as the ones responsible for the hoax.

Many of Kammerer's Austrian friends also were unable to believe that he was capable of so transparent a hoax. A few argued that academic hostility had led someone, perhaps Megusar, to commit the fraud. Others, however, felt that Kammerer was self-deluding. Among these was Dr. Richard B. Goldschmidt, a friend of Kammerer's, who wrote in *Science*, March 4, 1949, "I do not believe that Kammerer was an intentional forger. He was a very high-strung, decadent but brilliant man. . . . He conceived the idea that he could prove the inheritance of acquired characteristics and became so obsessed with this idea that he 'improved' upon his records. . . . In later years he probably became so absorbed with the necessity of proving his claims that he started inventing results or 'doctoring' them. Though the actual results of all this amounted to falsification, I am not certain that he realized it and intended it."

## Koch's Mighty Monsters

The apparent inability of Paul Kammerer to distinguish between fact and wishful fantasy cost him life and reputation. "Dr." Albert Koch, on the other hand, lived to an old age, robbed of credit for what was possibly an important archeological discovery because his name was smirched by hoaxing.

The self-styled doctor, who had left his native Germany for the United States about 1835, was a fossil-peddler by trade. With St. Louis as his headquarters, he roamed much of the southern United States digging up bones, exhibiting them, and selling them to museums. Koch's greatest coup came in 1845, when he went on tour with the "Hydrarchus," a magnificent fossil sea serpent 114 feet long, whose mounted skeleton weighed 7,500 pounds. Koch claimed to have found his Hydrarchus in Alabama, and hordes of curiosity seekers paid twenty-five cents apiece to view the awesome remains. Sea serpents had been a subject of public fascination for over a century; now, at last, one was on open exhibit. Hydrarchus was a majestic sight, a vast expanse of bleached bones, looking like a huge snake with small, paddle-like limbs. Visitors were thrilled. Only certain unromantic scientists raised doubts about the serpent's authenticity.

**Mr. Silverberg** examines many hoaxes in his latest book, *Scientists and Scoundrels*, which is being published in March by Thomas Y. Crowell Co.

Koch's sea serpent, they said, was nothing but a shameless fraud, and insisted that Hydrarchus had been assembled from the bones of at least five separate animals. Koch, they added, had cunningly magnified his monster by adding extra ribs and vertebrae. "These remains never belonged to one and the same animal," declared Jeffries Wyman, Professor of Anatomy at Harvard. Nor was Hydrarchus even a true serpent. "The anatomical characteristics of the teeth," Wyman wrote in the *Boston Journal of Natural History* in 1845, "indicate that they are not those of a reptile but of a warm-blooded mammal."

It was not the first time Koch had bamboozled the public; in 1840, he had unearthed a large mastodon skeleton in Missouri. He mounted it dramatically, interpolating the bones of other mastodons to create a truly jumbo specimen, and—the final flourish—attached the enormous tusks in such a way that they curved upward from the head like gigantic horns. He hauled this bizarre creature all over the country; by October, 1841, it was in Philadelphia, and the paleontologist Richard Harlan viewed it and praised "the perseverance of the enterprising proprietor, Mr. Albert Koch," while noting the errors of articulation and charitably hoping that "no doubt" Koch's later research "would enable him to rectify these errors."

Koch brought his mastodon to London a few months later. Its authenticity was challenged by Richard Owen, the well-known anatomist and paleontologist of the Royal College of Surgeons, but the public was enthusiastic, and more than a year passed before the vogue died and Koch moved to Dublin and then to Berlin. On his way back, in May, 1844, he sold the creature to the British Museum for a considerable sum; it was promptly stripped of its extra bones and the tusks were put where they belonged. The dehorned mastodon is still being exhibited. It resides in the Fossil Mammal Gallery of the British Museum.

Having won fame and some fortune with his mastodon, Koch next excavated and assembled his Hydrarchus. The raw material for the sea serpent was a seagoing mammal of a type Owen had found in fossil form in 1835—*Zeuglodon*, or *Basilosaurus*. In life, the animal had been almost sixty feet long and eight feet thick, with an enormous tail ending in great flukes like those of a whale, and tiny, paddle-like flippers. This would seem to be impressive enough, but Koch improved on the model.

Professor Wyman showed that Koch had strung together vertebrae from at least five zeuglodons to form Hydrarchus. He also pointed out that some of the "bones" in Hydrarchus' flippers were actually the fossilized shells of a mollusk, apparently one of the genus *Nautilus*. Koch was thoroughly discredited in this country and in England, but he scored a public triumph when he took Hydrarchus to Germany in 1846, and unloaded the beast to the Royal Museum in Berlin for a fine price. The following year, Koch had a new Hydrarchus on tour, taking it on an elaborate odyssey that lasted until 1853. A few years later, he settled down permanently in St. Louis and lived in semiretirement until his death in 1866, regarded locally as an important scientist and elsewhere as a charlatan.

## A Valid Discovery

ALL this would be of little importance to the history of science but for the fact that before his sea serpent exploits Koch apparently had made one discovery of the first rank. In October, 1838, a farmer digging a well in Gasconade County, Missouri, uncovered some large bones, a stone knife, and an Indian ax. Koch hurried to the site and obtained permission to excavate. In an account published anonymously in the January 12, 1839, issue of *The Presbyterian*, a Philadelphia weekly, Koch told how, below layers of clay and sand, he came upon charred bones, axes, spear points, and ashes—indicating that long ago some great beast had been slain and roasted by Indians. "The fire appeared to have been the largest on the head and neck of the animal," he wrote, "as the ashes and coals were much deeper here than in the rest of the body."

It was a find of major significance, demonstrating man's antiquity in the New World. The very fact that Koch first published his findings anonymously would seem to indicate that he regarded his discovery in a different light from his other "scientific" activities. For the bones were those of a long-extinct creature, a mastodon or perhaps a giant ground sloth—unmistakably hunted and devoured by contemporaneous human beings. Many theorists held that man had come to the Americas no earlier than the time of Christ; here was proof that he had arrived thousands of years earlier, when mastodons still roamed in the region that is now Missouri.

In 1841, Koch once again described his 1838 find, this time taking public credit for it. In a pamphlet headed *Evidence of Human Existence Contemporary with Fossil Animals*, he described his excavation in detail, giving a clear and respectably scientific account of his work, adding a new detail: "There was embedded immediately under the femur, or hind leg bone of this animal, an arrowhead of rose colored flint, resembling those used by the American Indians, but of larger size." Other arrowheads lay nearby. "These arrowheads," he concluded, "are indisputably the work of human hands."

## Honesty Is Questioned

KOCH's flamboyant exploits with his inflated fossils were to mark him as untrustworthy. Scientists read his pamphlet and spoke of his want of accuracy and lively imagination. To the end of his life, Koch defended the authenticity of his Gasconade County site, to no avail. The overwhelming strength of authority held that man was a newcomer to the New World, and that no human beings had ever hunted mastodons in North America. And so it remained until 1926, when J. D. Figgins of the Denver Museum of Natural History found weapon points *in situ* with fossil bison remains near Folsom, New Mexico, and conclusively showed that man's presence in the Americas could be dated back at least ten thousand years from the present.

The Folsom discovery was a landmark in American archeology; yet, but for Koch's tainted reputation, it might rate no more than a footnote today as confirmation of his 1838 excavation. Unscrupulous as he was in concocting the Hydrarchus, Koch quite probably was sincere in reporting the Gasconade County material. His reports on the find are sober, serious, and detailed. But thanks to his fondness for cash and public acclaim he is remembered today, not as a pioneer figure in American archeology, but as the man who built a sea serpent and a mastodon with horns.

Hoaxes are reprehensible, but they have their uses. They teach us by their frequency and cleverness to test, to weigh, to examine. "He that knows nothing doubts nothing," George Herbert wrote in 1640. We do not win our knowledge cheaply, and the hoaxers at least serve to prod us to scrutinize every assertion closely.

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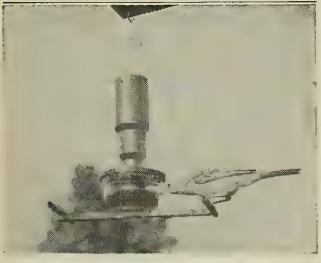

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Land and People in Nigeria. K. M. Buchanan and J. C. Puch. University of London Press, London, 1955.

Shifting Cultivation in Africa. Pierre DeSchlippe. Routledge and Kegan Paul, London, 1956.

## DAY LENGTH AND FOOD CACHES

Lives of Game Animals, Vol. IV. E. T. Seton. Doubleday, Doran & Co., 1929.

Notes on the Life History of the Small Eastern Flying Squirrel. D. E. Sollberger. *Journal of Mammalogy*, Vol. 21, pages 282-293, 1940.

## GREEN ALGAE DIVIDE TO MULTIPLY

The Fresh-water Algae of the United States. Gilbert M. Smith. McGraw-Hill Book Co., N. Y., 1950

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## MYSTERY OF A MILLIPEDE

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Chemical Defenses of Arthropods. L. M. Roth and T. Eisner, *Annual Review of Entomology*, Vol. 7, pages 107-136, 1962.

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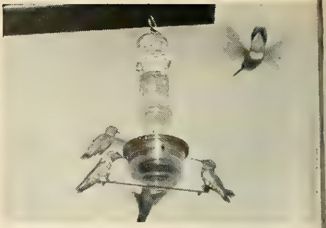
Sex of Host Specificity and Position Specificity of Certain Species of Laboulbenia on Bembidion Picipes. Richard K. Benjamin and Leland Shanor. *American Journal of Botany*, Vol. 39, pages 125-131, 1952.

## SPREAD OF A PARASITE

The Mistletoes: A Literature Review. L. S. Gill and F. G. Hawksworth. *U.S. Department of Agriculture Technical Bulletin No. 1242*, 1961.

Dwarfmistletoe of Ponderosa Pine in the Southwest. *F. G. Hawksworth. U.S. Department of Agriculture Technical Bulletin No. 1246*, 1961.



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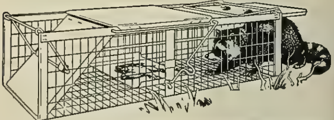

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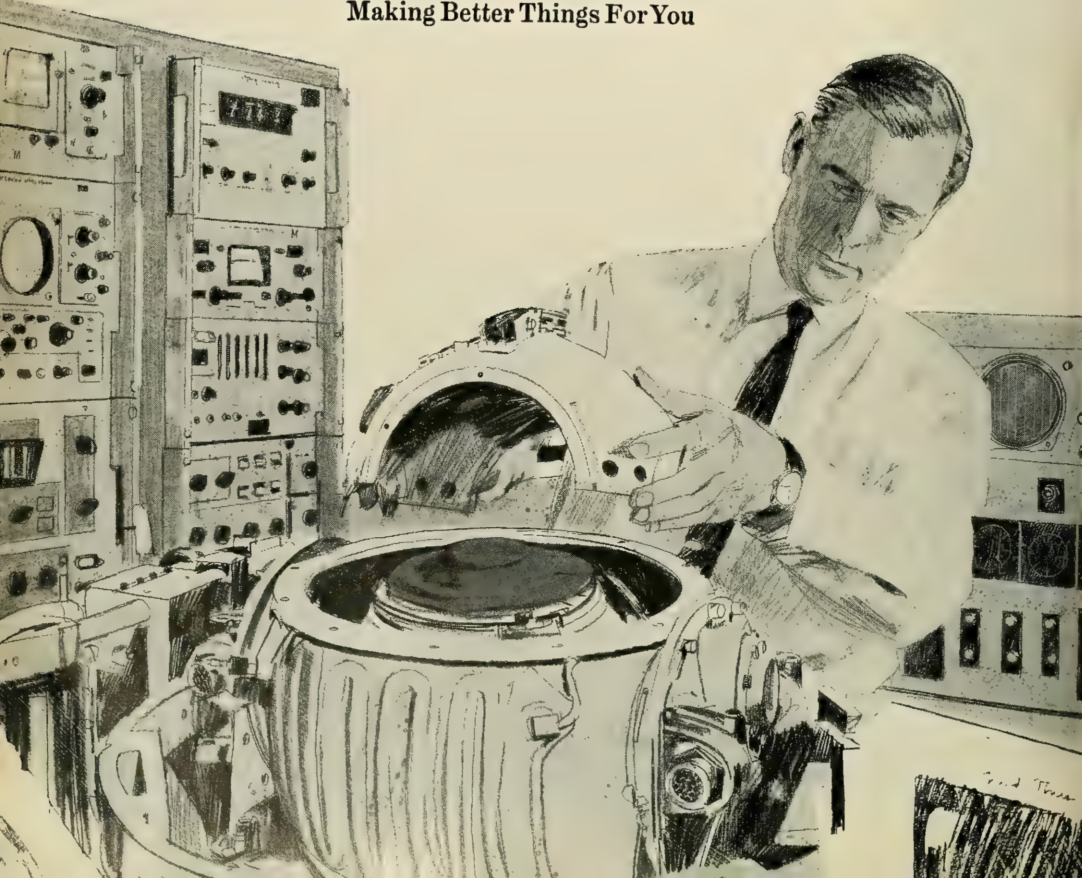

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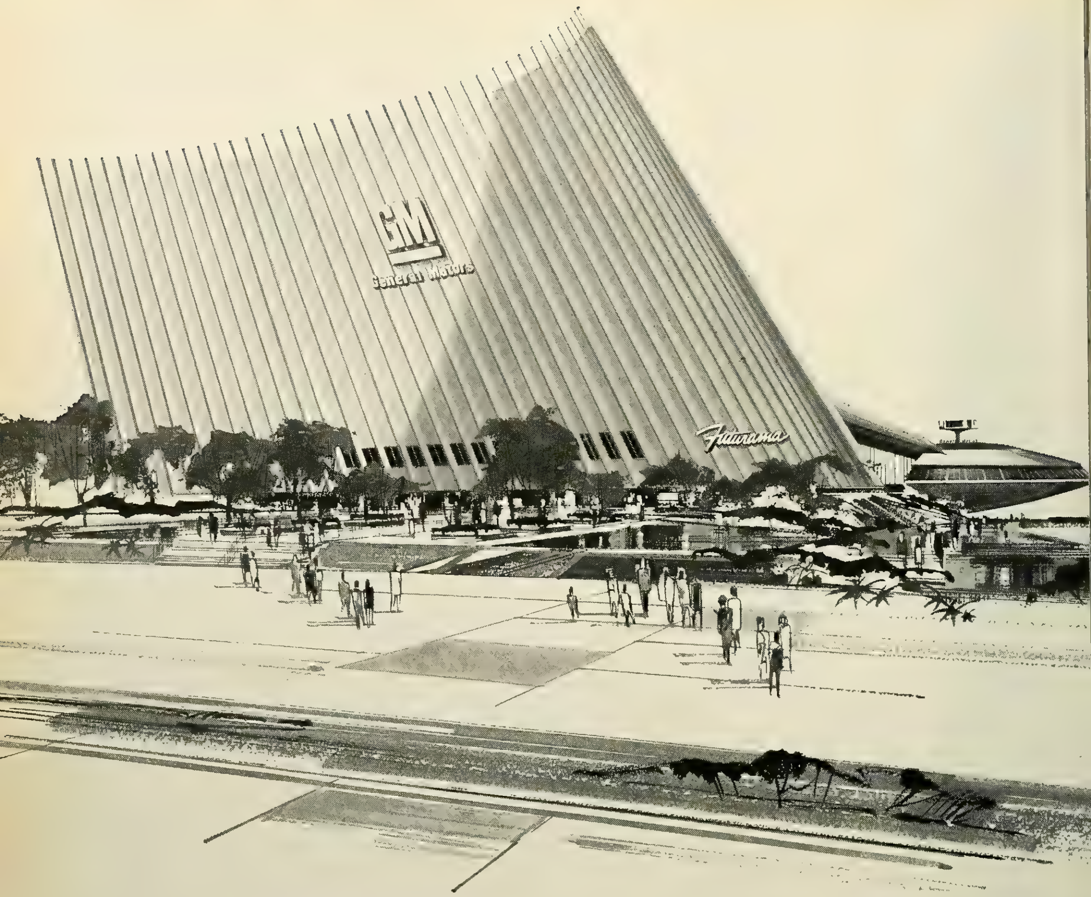

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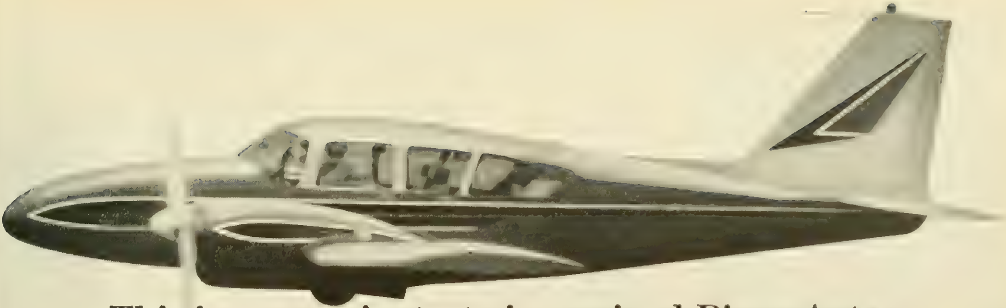

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Vol. LXXIV APRIL 1965 No. 4

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COVER: Set in a grove of date palms, St. Antony's Monastery is the first and oldest monastic building in the world. It was begun in the third century, in Middle Egypt, near the Red Sea. The church is typical of later Coptic religious buildings, with multiple domes lighted by small windows, a style derived from the Byzantine basilicas of Constantine and Justinian. Pagan reliefs adorning earlier temples are sometimes found under the plastered walls of Coptic churches. St. Antony, together with St. Paul, a hermit, was an originator of monastic life. Dr. John D. Cooney's article begins on page 40. Photograph is by George Holton.

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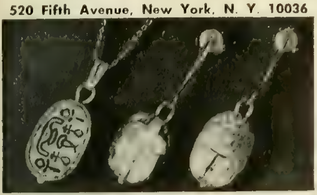

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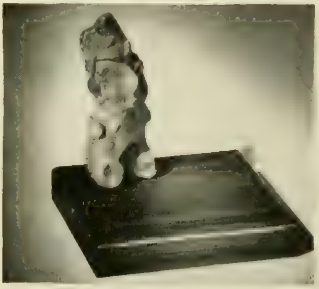

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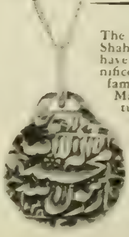

The heavy silver coins of the Shah Jahan Empire (1632-1653) have been transformed into magnificent handcrafted jewelry. This famed Indian ruler built the Taj Mahal, the worlds most sumptuous memorial to a beloved wife. Coins of Shah Jahan, historically symbolizing his immortal love for the Empress Mahal, are now available as regal charms, pendants & cufflinks. *A gift truly expressing eternal love!*

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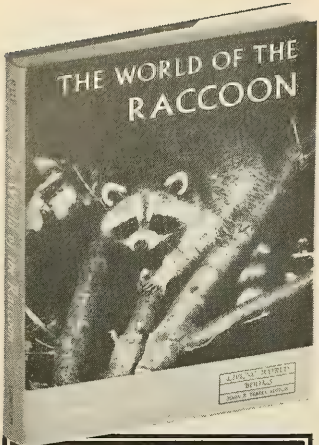

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**BOOKS IN REVIEW**

# Dedicated to mammals

### By Richard G. Van Gelder

Mammals of the World, by Ernest P. Walker. *The Johns Hopkins Press, Vols. I and II, $25.00; 1,568 pp., illus. Vol. III (bibliography), $12.50; 700 pp.* The Management of Wild Mammals in Captivity, by Lee S. Crandall. *The University of Chicago Press, $13.50; 761 pp., illus.* The Wild Life of India, by E. P. Gee. *E. P. Dutton & Co., $5.95; 192 pp., illus.* Dangerous to Man, by Roger A. Caras. *Chilton Books, $10.00; 433 pp., illus.* Cats of the World, by Armand Denis. *Houghton Mifflin Co., $5.95; 144 pp., illus.*

It is surprising that man, with all his scientific and technological sophistication, blindly refuses to recognize that he is an animal and a part of nature, and that he is just as subject to ecological principles as any other living creature. Instead, man chooses to view himself as the nucleus of a biological universe, with all other living things equated as either good or bad for man, or disregarded. It is perhaps unfortunate that the activities of only a small proportion of living things are directly related to man; the majority of fauna and flora is thus considered useless and therefore suitable for destruction should it be in the path of man's works. It is not strange, then, that the introduction to Ernest Walker's *Mammals of the World* reads, "To the mammals, great and small, who contribute so much to the welfare and happiness of man, another mammal, but receive so little in return, except blame, abuse, and extermination."

Considering the number of species of animals living today, the mammals comprise a comparatively small group—about one third of one per cent of the total known to science. The four thousand or so species of living mammals are, however, of considerable importance in the world's ecology because they are relatively large animals, because they are widespread, and because they often exist in sufficient numbers to cause notable and direct effects on their environment. And it is for these reasons that they are so markedly persecuted.

*Mammals of the World* provides accounts of every one of the 1,044 genera of modern mammals. Encompassed in these genera are the 4,287 species that are currently recognized. Nowhere else can a layman or scientist so readily become aware of how little he knows of the mammals. How many of the 2,032 species of rodents, the 796 species of bats, or 247 species of carnivores can you name?

The classification of species for many kinds of mammals is still the problem of the specialist, but although species are dealt with in each account, Walker has wisely chosen the more practical genus—to each of which he usually allots a page—as his level for discussion. Common names, numbers, and distribution of species are followed by measurements, colors, and other descriptive material. Each section concludes with more paragraphs of life history information, including food and breeding habits, behavior, and economic importance.

For almost every genus there is an illustration, generally a photograph of the animal, and for those alone the volumes must be lauded. The rarer species, some of which are known by only a single specimen, are represented by a photograph of the skull or dentition, or of the study skin, and the text usually tells in which institution the specimen may be found. These photographs range from a few poor ones to excellent, with the majority in the last category.

A useful 24-page chart entitled "World Distribution of Genera of Recent Mammals" is included, and the first volume contains a 114-page selected bibliography of some 4,500 titles, planned to obviate the necessity for most persons to purchase the third volume, a bibliography of more than 40,000 titles. Each of the first two volumes is identically indexed for common and scientific names only, and the end papers contain conversion tables for the metric system.

There is no question of the usefulness of these volumes. Every mammalogist must have them, and those who profess a broad interest in the fauna of the world will want them. Unfortunately, the arrangement of the bibliographical volume makes its use as a comprehensive source most difficult, if not impossible. (The selected bibliography in the first volume, while somewhat more usable because of its brevity, still contains an abundance of secondary sources of dubious value.) However, the third volume is sold separately. Well bound, well illustrated, on good paper, and highly usable, these compendiums of mammalogy are worth their price.

Some of the genera listed by Walker are already extinct. As cognizance of the disappearance of wildlife throughout the world becomes more widespread, various schemes are devised for preserving the remnants. One method of saving

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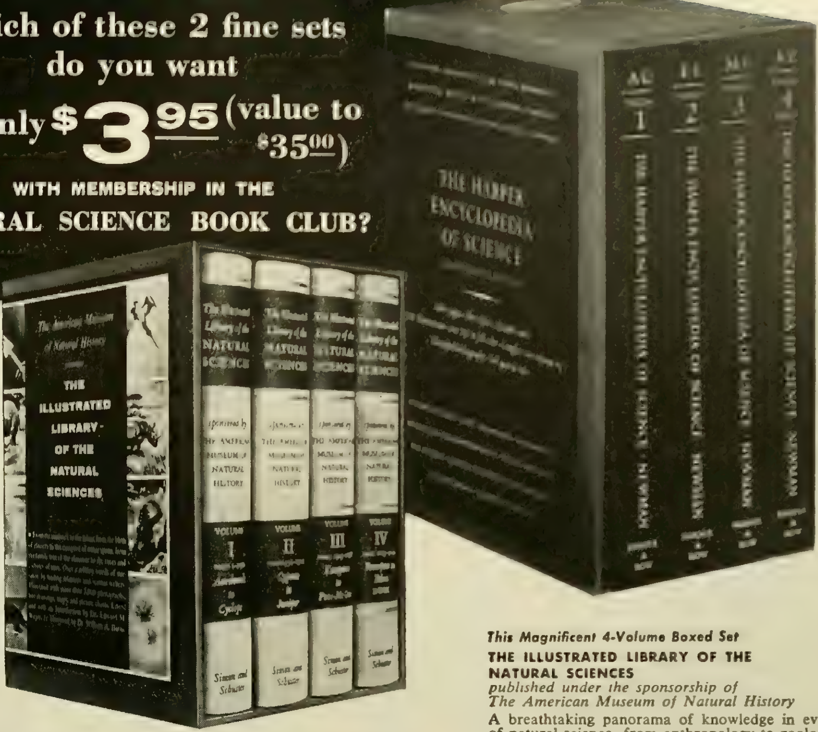

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species is by breeding them in zoological parks. While this concept has many undesirable features, it has the advantage of having worked. The European bison and Père David's deer are notable examples of animals that would be extinct were it not for zoos. The skills necessary for caring for wild mammals in captivity are rarely documented. Generally they are learned by expensive experience or, better, by word-of-mouth transmission from zoo men. With the publication of *The Management of Wild Mammals in Captivity*, by Lee S. Crandall, future animal handlers will be able to consult an authoritative, well-documented, and highly readable summary of this field.

Crandall not only draws on a wide literature, but on his own fifty years of experience at the New York Zoological Park (Bronx Zoo). He gives thorough coverage to the housing and feeding requirements of the animals, historical information, distribution, breeding habits and success of breeding in captivity, rearing of the young, longevity, causes of death, and myriad other subjects. This is highly enjoyable reading. Unquestionably, Mr. Crandall's book will rapidly become the primary source of information for those who keep wild mammals in captivity.

More desirable than keeping animals in zoological parks is maintaining them in their natural domains. Unfortunately, there is still great danger of species extermination in this method. Nevertheless, the success of this technique has been proved for certain species in various parts of the world.

That India, with a population of almost half a billion, and still a "happy hunting grounds" for the big game sportsman, should be undertaking major conservation programs is most meritorious. Certainly these should receive an impetus from *The Wild Life of India*, by E. P. Gee. Anyone who plans to travel to India will do well to have this book with him. The author takes the reader on a personal tour of many of the best of India's wildlife sanctuaries as he watches the lions of Gir, chases the wild asses of the Rann, or observes the pelicans of Andhra. Gee so obviously loves wildlife in its natural surroundings that his plea for conservation comes through with far more force than the usual superficial and impersonal demands. Each chapter is built around an animal and a locale, and because this is not an adventure book, it is adventurous and thrilling. The photographs, in color and black and white, are superb; the appendix of sanctuaries (with the best dates for visiting), zoos, and forest officers, and the glossary bespeak a thoughtfulness on the part of the author that will further the usefulness of this fine work.

One of the minor reasons given for the killing of certain mammals is that they endanger man's livestock or crops. While it is now rare to have a campaign against a species solely on those grounds, it must be remembered that there is eradication pressure on wildlife today because animals compete with man for food and space, or because they provide him with some item of commercial value.

Roger A. Caras' *Dangerous to Man* is subtitled "Wild Animals: A Definitive Study of Their Reputed Dangers to Man." This book, despite the subtitle, is far from definitive and, considering the small percentage of human mortality resulting directly from wild animals throughout the world each year, tends to cater to a facet of morbid human curiosity. Although a superficial examination seems to indicate a scholarly and authoritative work, a closer look reveals its relationship to the world of advertising: set up a straw man in the form of lurid newspaper accounts, and shoot it down with scientific "facts."

The scientific standards stated by the author in the introduction are often disregarded in the following pages. For example, anthropomorphism is maligned, but we find "fearless" elephants, "sullen" gorillas, and "truculent" rhinoceroses. Worse still is a decided anthropocentric interpretation of animal behavior; an attack on man by a large member of the cat family is viewed in the light of abnormal psychology.

For classification of mammals, Caras relies on Ivan Sanderson, with some of the following results: an unrecognizable table of cat classification on the opening page; on facing pages the Asiatic elephant (one species) is given two different species names; rhesus monkeys receive two different generic names.

In the section on venomous snakes, the copperhead—the species that bites more persons in the United States than any other—is listed or mentioned in five places, but discussed only as far as revealing that the venom "is weaker than that of the rattlesnake." A special section on rabies is outdated; if followed, it could result in death or paralysis.

The author's information was derived almost entirely from the literature and from correspondence with an impressively lengthy list of persons throughout the world. However, I do not believe that an ornithologist, taxidermist, or mammalogist is necessarily qualified as an authority on giant clam behavior, or that a professional writer qualifies as an authority on mammal classification or on animals of which he has no personal knowledge. There is an element in this book that is reminiscent of the confidence game. Let the reader beware.

For the aelurophiles, Armand Denis' *Cats of the World* will be most welcome. For many years there has been no book available in English that gives reason-

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ably complete and accurate coverage of the thirty-six living species in the cat family. While Walker's great work will provide concise information about the genera and considerable information about the species, Denis' book is designed for more leisurely reading, and contains much anecdotal material about cats, great and small. The arrangement of this work is continental, starting with the cats of Africa. This inevitably leads to complications with the lions, cheetahs, leopards, and other cats that live on more than one continent, and the reader who is concerned with a single species may have to look in more than one place for his information. North American and South American cats are grouped in a single chapter and, as in the other chapters, the smaller cats, for the most part, have very brief accounts. Surprisingly little is known of the habits of those felines that have not been the sport of hunters or the prey of trappers. *Cats of the World* is illustrated with some superb photographs. Unfortunately, the Maurice Wilson drawings of some of the rarer cats all look like fugitives from Japanese silk screens and are inaccurate in detail. Photographs of some of these are available and would be preferable.

*Dr. Van Gelder, a frequent contributor to these pages, is the Chairman of the Museum's Department of Mammalogy.*

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EUROPE: A NATURAL HISTORY. by Kai Curry-Lindahl. *Random House, $20.00; 299 pp., illus.*

THIS handsome book, the second in the series "The Continents We Live On," has 264 superb photographs of animals, plants, and landscapes. Among the latter are some full-page color pictures that are strikingly beautiful and excellently reproduced. Two or three of the black-and-white photographs, however, show poor judgment on the part of the photographer. For instance, there is one full-page picture, apparently taken from a very low-flying aircraft, of a flock of flamingos in the Camargue frightened off their nests in great confusion. The resulting destruction to eggs and/or young might well have been serious, and it is shocking to find such a picture in a book that makes so many strong pleas for conservation.

The most spectacular in a series of maps is printed in full color and commits a glaring error by showing the Caucasus and Transcaucasia (included here in Europe) as covered with steppes, whereas much of this region is covered by luxuriant forest and, in the west, receives the greatest amount of rainfall in "Europe." Of course, Curry-Lindahl knows better and he does not make this error in the text. The great wealth of other good illustrations, however, more

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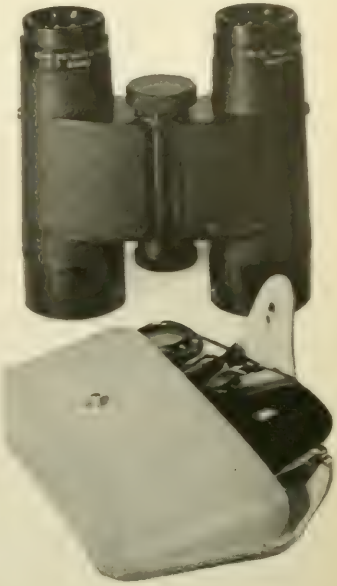

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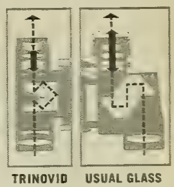

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than compensates for these blemishes.

The text is instructive and reflects the author's great experience as an ecologist and conservationist. He has traveled widely in Europe and his accounts are usually based on personal observations. He divides Europe into eighteen regions and each forms the subject of a separate chapter. But these regions are of unequal importance and their descriptions, followed by a list of animals and plants, tend to become monotonous. Perhaps a breakdown based on fewer regions of major ecological importance would have been more legitimate and comprehensive.

The text is overbalanced by its profuse and brilliant illustration, and I do not know if it should be reviewed as a picture book or as an introduction to the natural history and ecology of Europe. On either ground, however, it deserves success.

CHARLES VAURIE
*The American Museum*

THE NATURAL GEOGRAPHY OF PLANTS, by Henry A. Gleason and Arthur Cronquist. *Columbia University Press, $10.00; 420 pp., illus.*

VEGETATION is a complex, dynamic, and geographically variable natural phenomenon. To understand and enjoy this aspect of our environment more fully, one must appreciate its complexity and variations, recognize its correlations with the changing patterns of climate and soil, and consider its origins. All of us are aware of some of these aspects of plant life. Our awareness will be enhanced and expanded by reading *The Natural Geography of Plants.*

This well-designed, straightforward introduction to plant geography was written by two outstanding plant scientists, Henry Gleason and Arthur Cronquist—both members of the curatorial staff of The New York Botanical Garden. Their text is composed of a progressively arranged selection of some ninety important principles of plant geography. Each is discussed and illustrated by examples that "can be seen in one's own vicinity, as one either drives across the country or strolls through the woods and fields." With the aid of a superb collection of photographs of individual plants and of vegetation types, the authors have accomplished the enviable feat of presenting a complex subject in a clear and understandable manner.

Professional botanists will find the book interesting as a vehicle for the presentation of Dr. Gleason's concepts of the "individualistic approach." The basic assumption of the text is that "Every feature of the general distribution of plants over the world is due to the combination, in varying patterns, of the separate individual distributions of all kinds of plants." Other hypotheses are not discussed and, unfortunately, Gleason's ideas are not supported by any concrete data, although such data have been accumulated recently—especially by the late John T. Curtis of the University of Wisconsin and his students.

My chief criticism of the book is that its authors regularly ignore a basic fact that they set forth early in the text—a plant has no perception. Yet throughout the book they employ innumerable anthropomorphisms, such as "likes to grow," "sun-loving plants," "prefers wet soil," "lime-loving," "shade-loving," etc. Such illogical phrases mar an otherwise excellent work.

JACK MCCORMICK
*Academy of Natural Sciences of Phila.*

ASTERISKS, by James S. Pickering. *Dodd, Mead & Co., $4.00; 214 pp., illus.*

SUBTITLED "A Book of Astronomical Footnotes," *Asterisks* is the result of a series of ninety-nine one-minute radio scripts by Mr. Pickering, Assistant Astronomer at The American Museum-Hayden Planetarium. All phases of astronomy are covered, from white dwarfs to red giants, from artificial satellites to galaxies, from early astronomical records, such as the supernova of 1054, to the recent development of radio astronomy. Astronomical structures range from the Tower of Babel to the Mount Palomar Observatory.

The few errors I noticed are minor: Sputnik I was launched in 1957 (not in 1956); Russell W. Porter died in 1949 (not in 1947); did Galileo really see "millions of stars"? I doubt it; and on one page, the curvature of a path is incorrect. The reproductions and diagrams are well chosen, although an enlarged, fuzzy image of Mercury remains, as always, a disappointment.

Recent "space" astronomy is kept in its place; this book reaffirms that, after all, astronomy has been practiced and studied since the beginning of man. I appreciate the author's concern with the all-important historical development of astronomy, his treatment of such "old-fashioned" topics as parallax, proper motion, solar motion, and precession. A chapter titled "Falling Around" admittedly is the simplest and most descriptive way of presenting the combined effect of inertia and centripetal acceleration.

The book remains what the original "asterisks" were intended to be: brief, concise, and accurate statements of facts. Thus restricted, the author has acquitted himself well.

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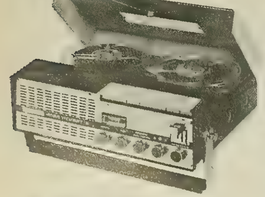

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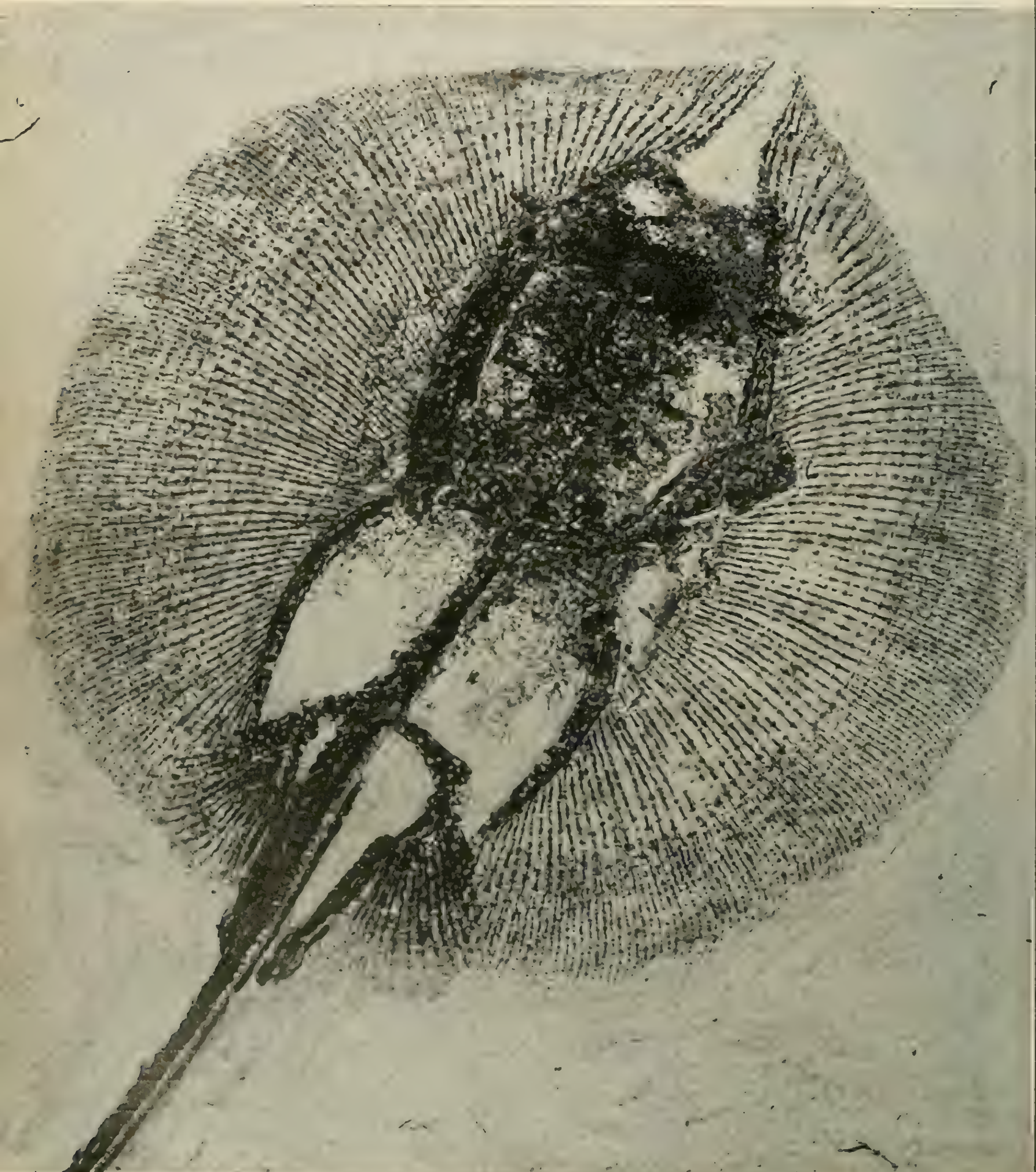
# Fossil Lakes from the

Green River Formation discloses its 10-million-year history



# Eocene

By Bobb Schaeffer
and Marlyn Mangus

During the late summer of 1868, Ferdinand Vandiver Hayden, Director of the newly established Geological and Geographical Survey of the Territories, traveled westward along the Overland Stage Route from Fort Sanders, near Laramie, to Green River, Wyoming. He and his party of nine—outfitted with a two-horse ambulance, four mules, a covered wagon, four riding animals, and three tents—were engaged in a geological reconnaissance of the Wyoming Territory, supported by a $5,000 grant from Congress.

Along the Green River between the towns of Rock Springs and Green River, Hayden observed a distinctive sequence of rocks that he described in his report of 1869: "A little east [Hayden undoubtedly meant west] of Rock Spring station a new group commences, composed of thinly laminated chalky shales, which I have called the Green River shales, because they are best displayed along Green River. They are evidently of purely fresh-water origin, and of middle tertiary age. The layers are nearly horizontal, and, as shown in the valley of Green River, present a peculiarly banded appearance. When carefully studied these shales will form one of the most interesting groups in the West. The flora is already very extensive, and the fauna consists of *Melanias*, *Corbulas*, and vast quanties [*sic*] of fresh-water fishes, preserved in much the same way as those in the Solenhofen slates of Germany. There are also numerous insects and other small undetermined fossils in the asphaltic slates. One of the marked features of this group is the great amount of combustible or petroleum shales, some portions of which burn with great readiness, and have been used for fuel in stoves."

To Hayden goes the credit for first describing and naming the lacustrine, or lake, deposits now known as the Green River Formation. But before long other eminent geologists were reporting on the lithology and occurrences of these rocks. In 1876 John Wesley Powell described sections of the Green River Formation in the foothills of the Uinta Mountains in northern Utah. In 1878 Clarence King and C. A. White reported occurrences in the Washakie Basin and as far north as the Wind River Mountains in the Green River Basin. A. C. Peale observed the same rocks in northwestern Colorado, 150 miles south of Hayden's type locality. It soon became apparent that the Green River Formation covers several areas of vast extent; today the total is estimated at 34,000 square miles, or roughly the combined sizes of Lake Huron and Lake Erie.

**Fossil sting ray has 9-inch disk. It may be related to the living *Dasyatis*.**

Parachute Creek Canyon is near Meeker, Colorado. Its sharply cut walls show excellent exposures of strata in Green River Formation.

In Hayden's opinion the Green River Formation was of fresh-water origin. This opinion was shared not only by the other geologists working in the region at that time but also by the vertebrate paleontologists E. D. Cope and O. C. Marsh. An earlier idea that the Tertiary sediments of this region were marine was essentially corrected when it was realized that the invertebrate fossils were fresh-water forms. Although most of the Tertiary deposits in the West are of flood plain origin, the Green River Formation is a notable exception in being lacustrine. It originated as limy muds and sands laid down in several lake beds during the Eocene. These lakes occupied two intermontane basins in southwestern Wyoming, and another in central Utah and northwestern Colorado.

The story of the Green River lakes actually began about seventy million years ago, at the close of the Cretaceous Period. At that time a great seaway, which extended across western North America from Alaska to Mexico, was gradually diminishing in size (by Early Tertiary it had completely disappeared), and the thick layers of sediments that had been deposited in it were being slowly uplifted and folded to form mountains. The present Rocky Mountains are a result of this interval of mountain building, often referred to as the Laramide revolution. In North America the beginning of this orogeny marks the end of the Mesozoic Era (Age of Dinosaurs) and the onset of the Cenozoic Era (Age of Mammals). The Cenozoic itself is divided into the Tertiary Period (lasting about sixty-nine million years) and the subsequent Quaternary Period (lasting about one million years). In turn, the Tertiary is divided, mainly on the basis of mammalian faunas, into intervals of varying lengths called epochs. The first two epochs of the Tertiary, with which we are concerned directly, are the Paleocene and the Eocene. Together they cover an interval of approximately twenty-seven million years.

It must be remembered that while the whole western portion of the continent was being raised, the mountain chains themselves were being elevated more rapidly than the surrounding country. The Rockies, which eventually attained an elevation of 13,000 to 14,000 feet, were probably no more than 4,000 to 5,000 feet high in the Early Tertiary. As these new mountain ranges rose they created intermontane basins, and new drainage patterns were established. Streams from the surrounding highlands deposited muds and sands on the basin floors, forming vast alluvial plains. Volcanoes were intermittently active and volcanic ash was widely distributed. As the sediments continued to accumulate, local down-warping (lowering of the basin floors) occurred, and drainage was obstructed. Ponds began to develop at places along the streams, and some grew into extensive, shallow lakes.

The first lake of appreciable size developed in the Great Basin of central Utah during the Paleocene. This shallow sheet of water, called Lake Flagstaff, extended from the present location of Bryce Canyon northward almost to Provo. The vast quantities of limy muds and volcanic ash that accumulated on the lake floor form the Flagstaff Formation, which in places is as much as 1,500 feet thick. Technically speaking, Lake Flagstaff is a precursor of the Green River lakes, but is included here because its depositional history forms a continuum with the first Green River lake in Utah. As a result of flood plain deposition or local upwarping, Lake Flagstaff was gradually reduced in the south. It persisted in the north, however, and expanded eastward into the Uinta Basin to form Lake Uinta. At this time, by now Early Eocene, black clay muds began to accumulate in the lake. The black shales formed from these earliest deposits in Lake Uinta represent the basal unit of the Green River Formation in the Uinta Basin.

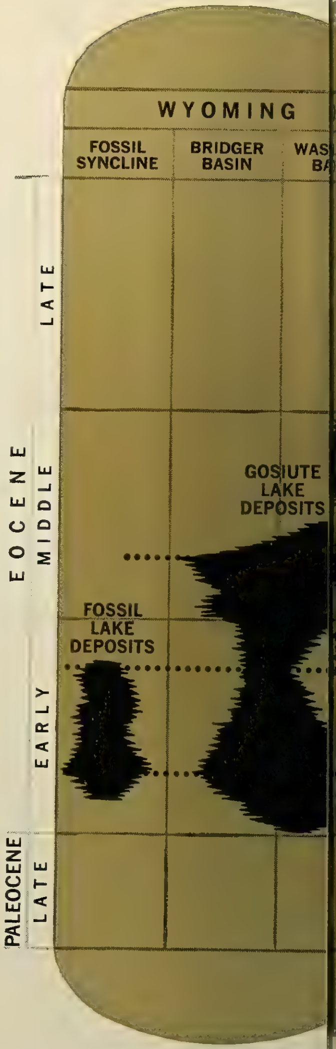
At the time Lake Uinta was expanding eastward, two other lakes were forming north of the Uinta Mountains in Wyoming. One of these, Fossil Lake, lay in a long, narrow depression west of the present city of Kemmerer. The other, Gosiute Lake, occupied the Green River and Washakie basins to the east. A dome of older Paleozoic and Mesozoic rocks—the Rock Springs uplift—probably formed an island in the center of this lake. The limy muds, sands, and volcanic ash deposited in the lakes eventually became the shales and sandy limestones typical of the Green River Formation.

Throughout their history the lakes fluctuated in size and shape, and their sediments consequently intertongue extensively with the surrounding flood plain deposits. Toward the end of the Early Eocene, Lake Uinta extended eastward some 60 miles into Colorado, nearly as far as today's town of Meeker. At its western end, however, streams were building up extensive deltas, which today can be recognized by sediments much coarser than the usual lake deposits, a situation that continued throughout much of Lake Uinta's history. During the same time Gosiute Lake suffered a period of contraction because of rapid deposition of flood plain sediments and perhaps a decrease in rainfall.

Just before the beginning of Middle Eocene time, Gosiute Lake again expanded around the Rock Springs uplift, this time surpassing its former maximum extent. Fossil Lake had disappeared, but in its general outline Lake Uinta remained virtually unchanged. Through the Middle Eocene Gosiute Lake was once more gradually reduced in size by the encroachment of flood plain deposits, primarily from the west. Large amounts of ash in the lake sediments laid down during this time indicate that volcanoes were particularly active. By the beginning of the Late Eocene, Gosiute Lake had apparently disappeared. Lake Uinta persisted into the Late Eocene; then it, too, gradually shrank and disappeared.

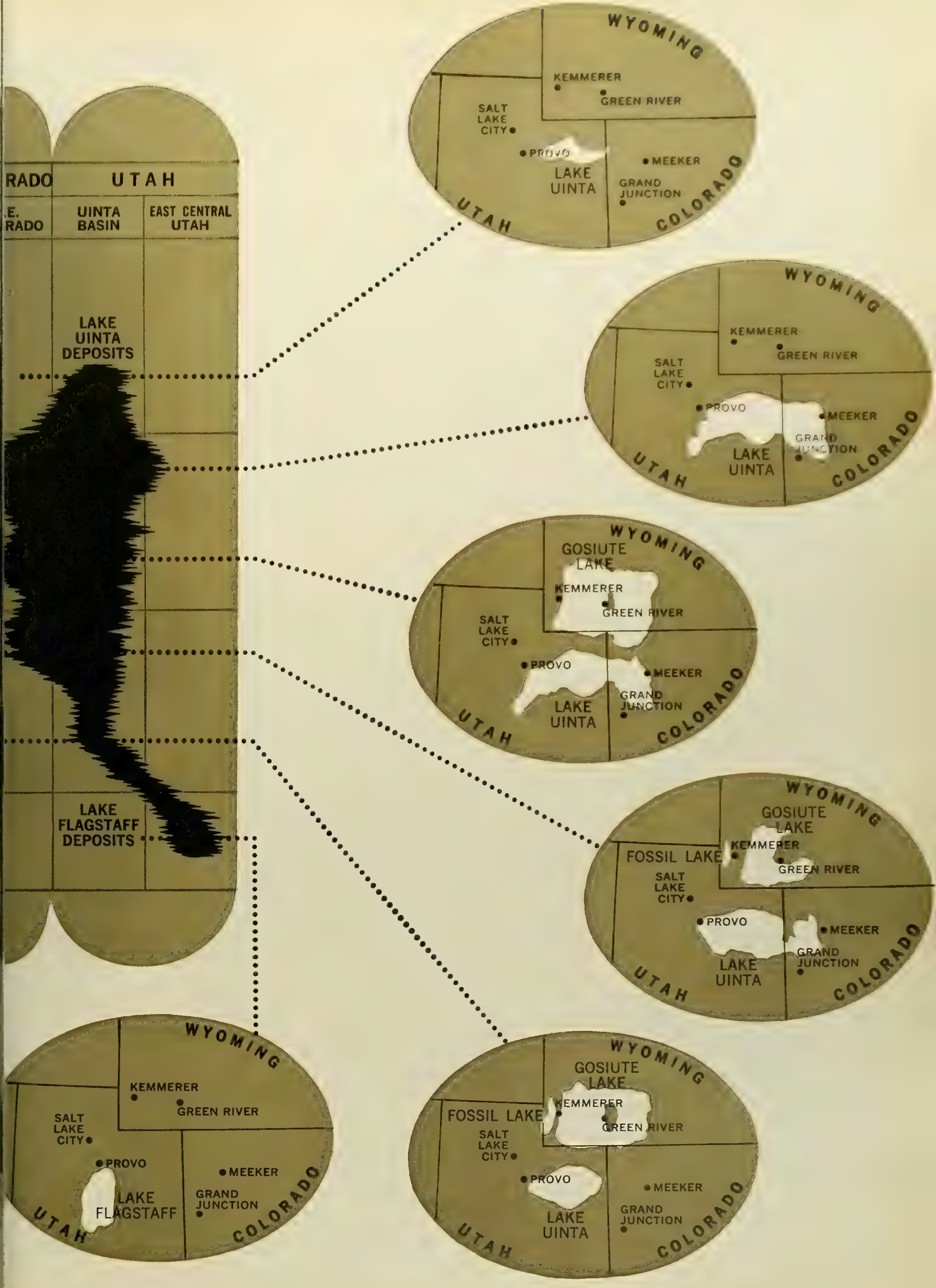
The fluctuations in size and shape of the Green River lakes throughout their history reflect a corresponding fluctuation in climate and tectonic (structural) conditions. The final disappearance of the lakes probably was brought about by a general uplift of the region. Rejuvenated streams carried vast quantities of flood plain material out over the lake beds and buried the lacustrine sediments. During the some forty million years since this event, two other processes have been at work. One of these is lithification—the conversion of loose sediments into indurated rock. Chiefly through cementation, reorganization, and compaction, the sediments that were deposited in the lakes were changed into sandy limestones and limy shales. The other process is really two processes—weathering and erosion. After the rejuvenated streams had reduced the upland areas, they began to cut down through the very sediments they had deposited earlier, and eventually into the Green River Formation itself. Today the Green River rocks are exposed at the surface in many places, and fine sections can be seen in numerous valleys and canyons.

Although the lithology of the Green River Formation is not uniform, limy shale represents by far the most common kind of rock. The shale itself, which is actually a kind of marlstone, is characteristically made up of very thin layers, or laminae, ranging from 0.014 to 9.8 millimeters in thickness.



FORMATION DISTRIBUTIO

Chart shows temporal and geograp distribution of Flagstaff and Gre River Formations in Colora Utah, and Wyoming. Maps at right indicate approximate areas the lakes at six different intervals time throughout their long histo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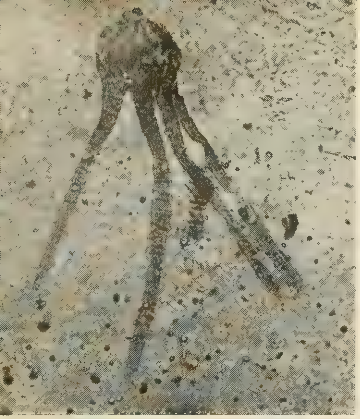
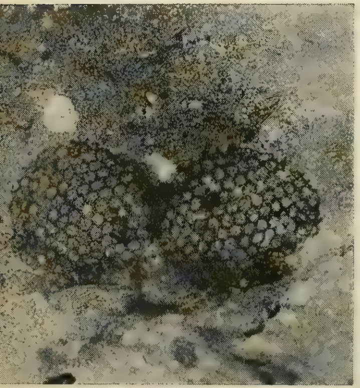
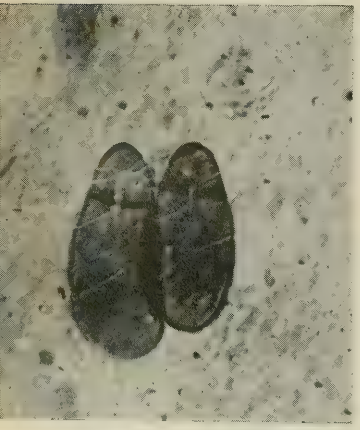


**Microfossil, magnified ×400, is the thallus of *Eoglobella longipes,* an alga. Appendages attach to one cell.**



**Eyes of minute, adult insect are at ×120 magnification. Often pairs are found attached to the head of insect.**



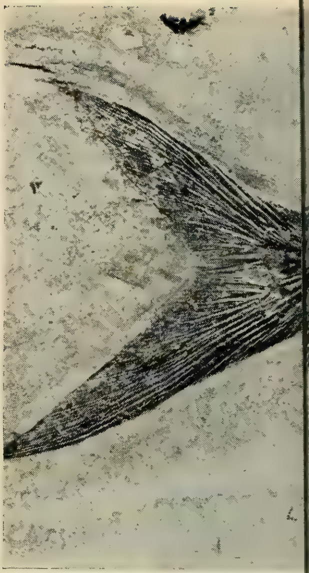
Fungus spores may be ascospores or conidia. If the latter, they may be of a living genus like *Didymella.*

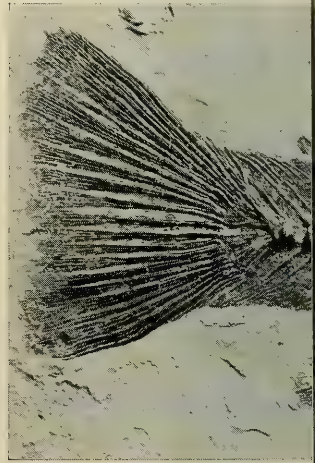
In many beds these laminae are alternately light and dark in color. Various explanations have been given to account for this, but most geologists agree that it was caused by a cyclical change related to annual depositional rhythms. Thus a single light layer, composed chiefly of carbonates, and a single dark layer, consisting of amorphous organic matter and lesser amounts of carbonate particles together represent the total deposition for one year. By counting the paired laminae for a foot and multiplying this figure by the thickness of the formation in feet, we can calculate that the lakes had a total duration of eight to ten million years.

One of the marked features of the finely laminated shale is its combustible quality, which Hayden noted in his report of 1869. Even earlier, during excavation for the Union Pacific roadbed west of the town of Green River, workmen ignited a bank of shale that burned for several days and reputedly provided enough illumination for night work. And not far away in northwestern Colorado, a settler named Mike Callahan used the same sort of shale to build a fireplace. The first time he made a fire the shale ignited and his house burned down.

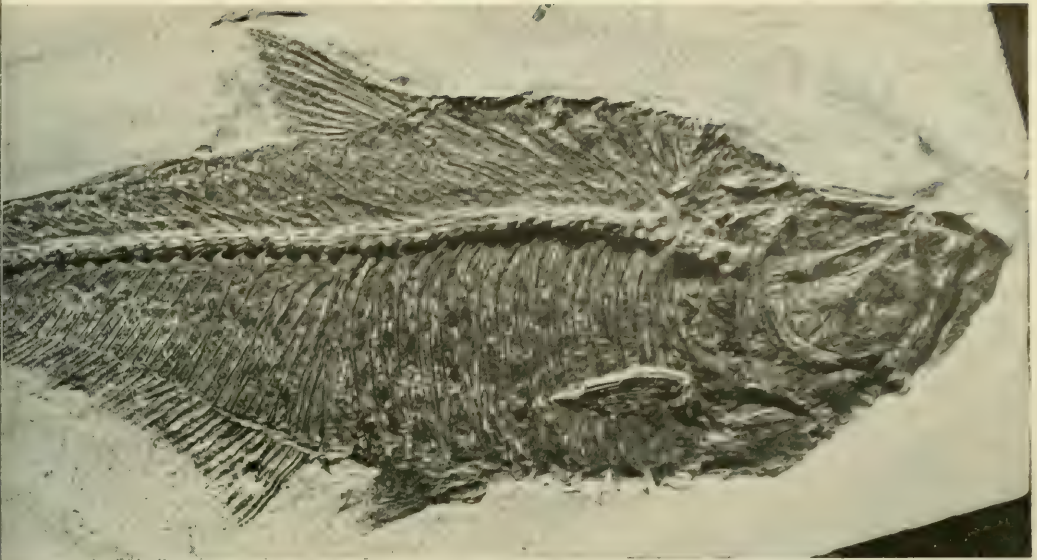
The combustible element in the Green River Formation is a solid, insoluble, organic substance called kerogen. When heated to a sufficiently high temperature, kerogen decomposes into oil, gas, and a carbonaceous residue. As a future source of petroleum, the Green River shales have an inestimable value. The Piceance Creek Basin (in northwestern Colorado) alone, for example, has a potential reserve of some 600 billion barrels. Under present production methods, however, the conversion of oil shale into high-grade crude oil is not economically feasible as long as petroleum can be pumped from the ground in sufficient quantities to meet our needs.

Aside from its economic aspect, the Green River Formation has long been famous for the wide variety of beautifully preserved fossils it contains. Studied in conjunction with the rocks themselves, these can provide us with an amazingly complete picture of the environment of the lakes.



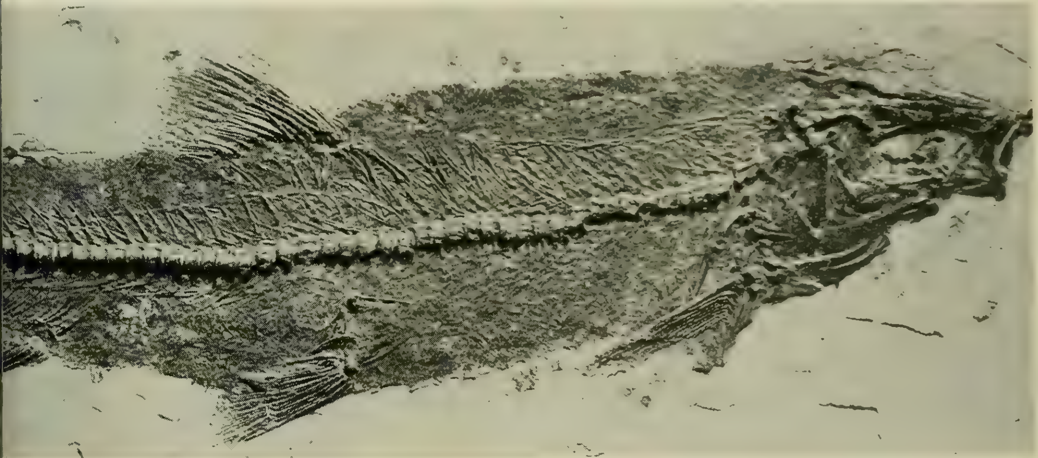


The climatic conditions, inferred primarily from paleobotanical evidence, have been described in detail by Dr. Wilmot H. Bradley of the United States Geological Survey, who has spent many years studying the Green River Formation. The fossil plants indicate a generally warm, temperate climate, but present a dual aspect. Some forms suggest a warm, moist lowland, and others a cooler, and probably drier, upland, as will be discussed later. A flora similar to the one represented by the Green River fossils can be found in the southern Atlantic or Gulf Coast states today—for example, in Alabama. Partly on the ba-



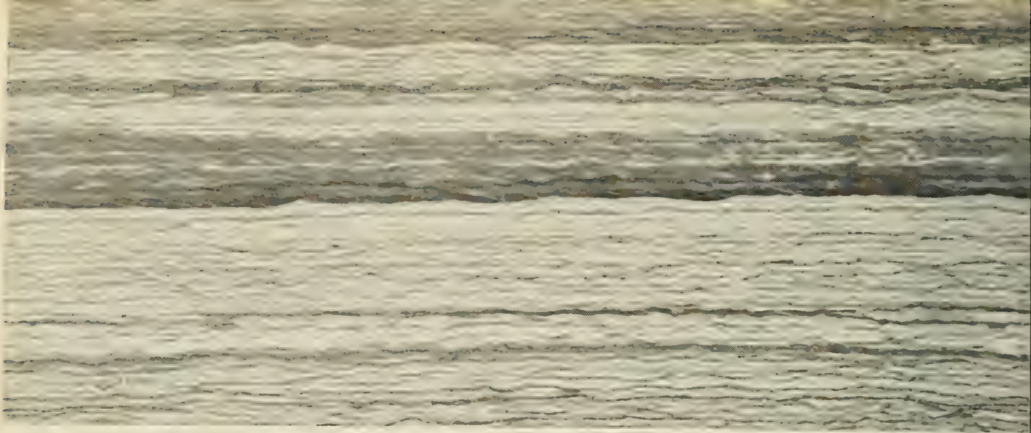
**Largest herring in Green River Formation is *Diplomystus dentatus.* Specimen above is approximately 18 inches long.**

**Relatives of *Notogoneus osculus* now live in the coastal waters of western Pacific. Fossil below is 22 inches long.**



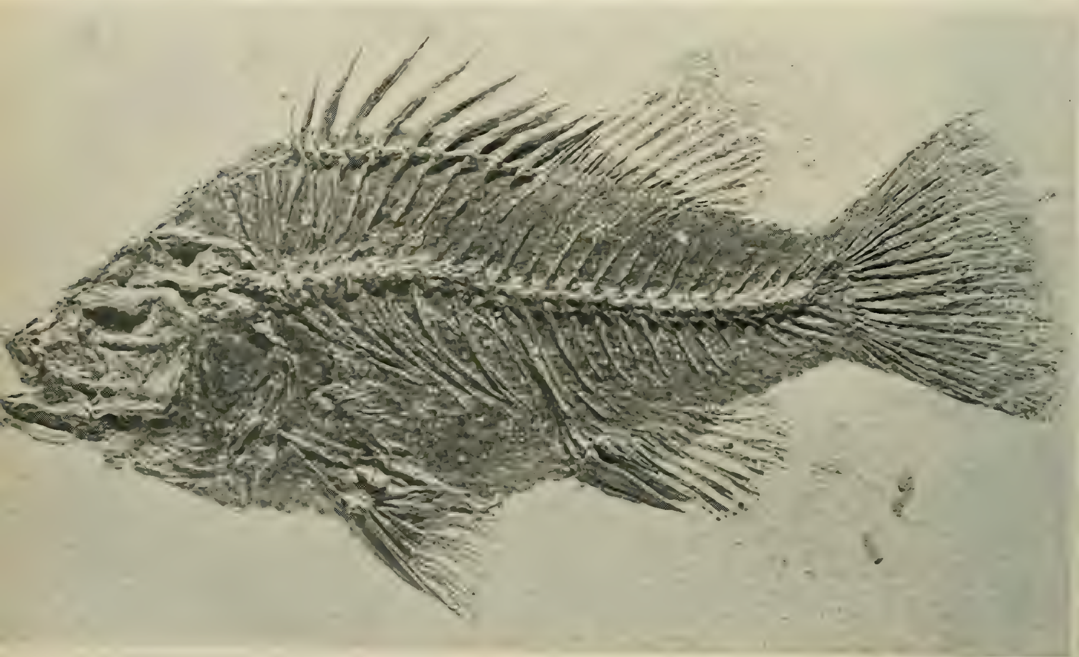
sis of this analogy, Dr. Bradley has calculated the probable rainfall and temperatures during the deposition of the Green River Formation. He estimates an average annual rainfall of 30 to 40 inches, and a mean annual temperature of 65° F. But because the lakes were far from the oceans, the temperature throughout the year probably varied considerably around this mean. It is not unreasonable to assume that it approached freezing in the winter and rose high enough during the summer months to create a long, hot season. Of course, such a climatic regime was not uniform throughout the history of the lakes. The presence of mud cracks and deposits of saline minerals probably reflect periods of decreased rainfall, as well as tectonic changes affecting the lake outlets. Although most of the saline minerals are relatively rare, one called trona is abundant enough to be of importance as a source of sodium carbonate.

Bradley pictures the Green River lakes as broad sheets of water some 10 to 15 feet deep near the shore and perhaps as much as 100 feet deep in the middle. Carbonate-secreting algae flourished and built up extensive reefs across the floors of the shallower parts of the lakes. Here, too, lived snails, clams, fly maggots, and aquatic insects. The fossil remains of these organisms suggest that they may have been preserved by rapid burial in place. The bottom environment in the deeper parts of the lakes was, however, quite



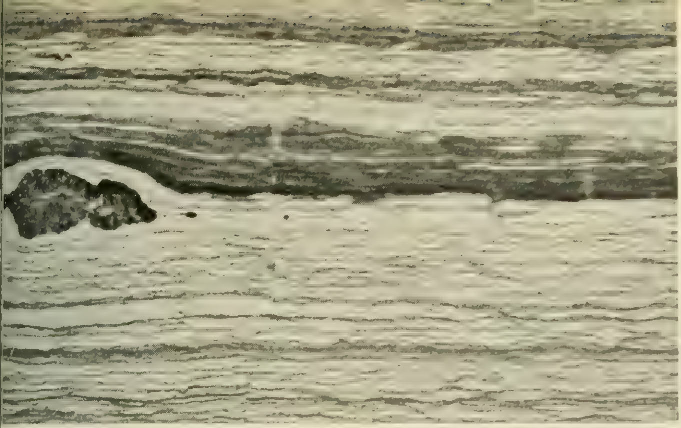
**Enlargement** of a polished section of Green River shale shows dark and light laminae and coprolite—fossil feces.

**Bass,** ***Priscacara*** **sp., is common in Fossil Lake deposits. Specimen shown below is a little over 9 inches in length.**



different from the shallow areas. The preservation of varves indicates that the water was extremely calm and that it was thermally or chemically stratified, as well. Under such conditions the lowest layer of the water would become stagnant and lose its oxygen. With the exception of anaerobic bacteria, life could not have existed there. Microscopic organisms from the upper layers, along with spores, pollen grains, and parts of insects, settled to the bottom and became part of an organic ooze. Leaves frequently remained intact long enough to leave sharp impressions in the hardening sediments. The soft tissues of dead fishes that drifted to the bottom decomposed, but the skeletons often were preserved with no displacement.

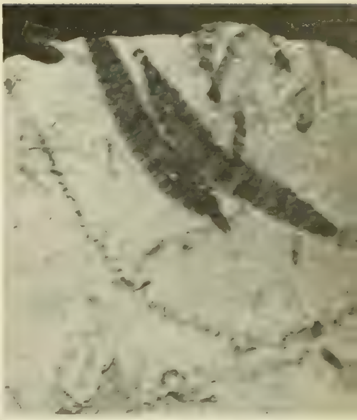
The lake waters were probably always rich in dissolved salts such as calcium, sodium, and magnesium carbonates that were brought in by streams from the adjacent highlands, and there were times when the salinity became so high that layers of salts were precipitated. But when high salinity was not prevalent, the conditions in the lakes must have been at an optimum for supporting an abundance of microscopic and macroscopic aquatic plants. The structureless organic matter found throughout the shales probably represents decomposed plant and animal material that originally must have been similar to the algal ooze found in some present-day lakes in Florida and central Africa. Ooze of this sort, which is the result of bacterial action, was mainly responsible for the kerogen.



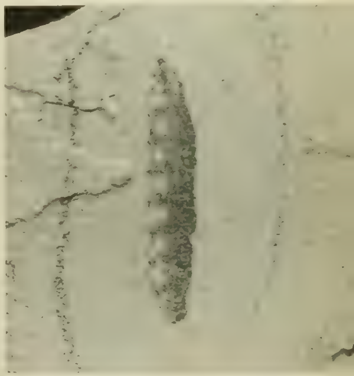
THE fossil fishes for which the Green River Formation is particularly famous were collected as early as 1856. In that year a geologist named John Evans obtained a specimen, possibly from the Green River Basin, which he sent to Dr. Joseph Leidy in Philadelphia. Leidy identified it as a herring, which later was called *Knightia humilis.* Several years afterward, when the Union Pacific Railroad was being built through southwestern Wyoming, a wide variety of fishes was discovered during roadbed excavations. Although fishes have been found in many places throughout the Green River Formation, the most famous locality is around the now-defunct town of Fossil, west of Kemmerer, Wyoming. For nearly a hundred years both professional and amateur collectors have been obtaining specimens from this locality for museums and private collections all over the world. At the present time an effort is being made to have Fossil Butte designated as a national monument in order to preserve this unique site.

The fish assemblage in the Green River Formation is a curiously mixed one in terms of present-day fresh-water fish faunas in the Northern Hemisphere. A sting ray, probably belonging to the living genus *Dasyatis,* is known from many delicately preserved specimens. Since the sting ray is a bottom feeder, it must have lived in places where the lake bottom supported abundant clams and other hard-shelled invertebrates. The paddlefish (*Polyodon*), with a living relative in China, is represented by a few specimens. It may have been primarily an inhabitant of the small rivers that drained into the lakes. The living paddlefish feeds on tiny organisms suspended in the water, and it is possible that the ancient ones were attracted to the lakes by an abundance of food. Paddlefish were present in Cretaceous ponds and streams so the Green River ones probably represent survivors from the Age of Dinosaurs. Remains of the gar *Lepisosteus* are locally abundant in the sediments of Lake Uinta, and beautiful specimens are occasionally found around Fossil. The gar and the bowfin, *Amia,* were active predators that lived in the lakes and in surrounding rivers and streams. Both were also present in the Late Cretaceous of western North America and still survive in many parts of the continent.

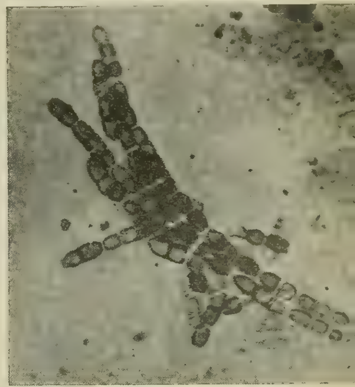
The most abundant and diversified bony fishes now living, called the teleosts, are represented in the Green River by at least nine genera. The most common and widespread are two kinds of herrings—the previously mentioned *Knightia,* and *Diplomystus.* They are often referred to as double-armored herrings because they have a row of characteristically modified scales, or scutes, along the mid-line of the back from the skull to the dorsal fin. Fishes of this type exist today in the coastal waters of Peru and eastern Australia. Although they are primarily marine, herrings have invaded fresh water many times. *Diplomystus* is known from Cretaceous rocks of Syria and Brazil and from the Tertiary of Brazil, West Africa, and possibly Europe, while *Knightia* has also been found in Tertiary beds in South America. Herrings usually move about in large schools, feeding on plankton. Slabs of Green River shale have been found covered with hundreds of *Knightia* specimens, indicating mass mortality of whole schools. The reason for the apparently simultaneous death of large



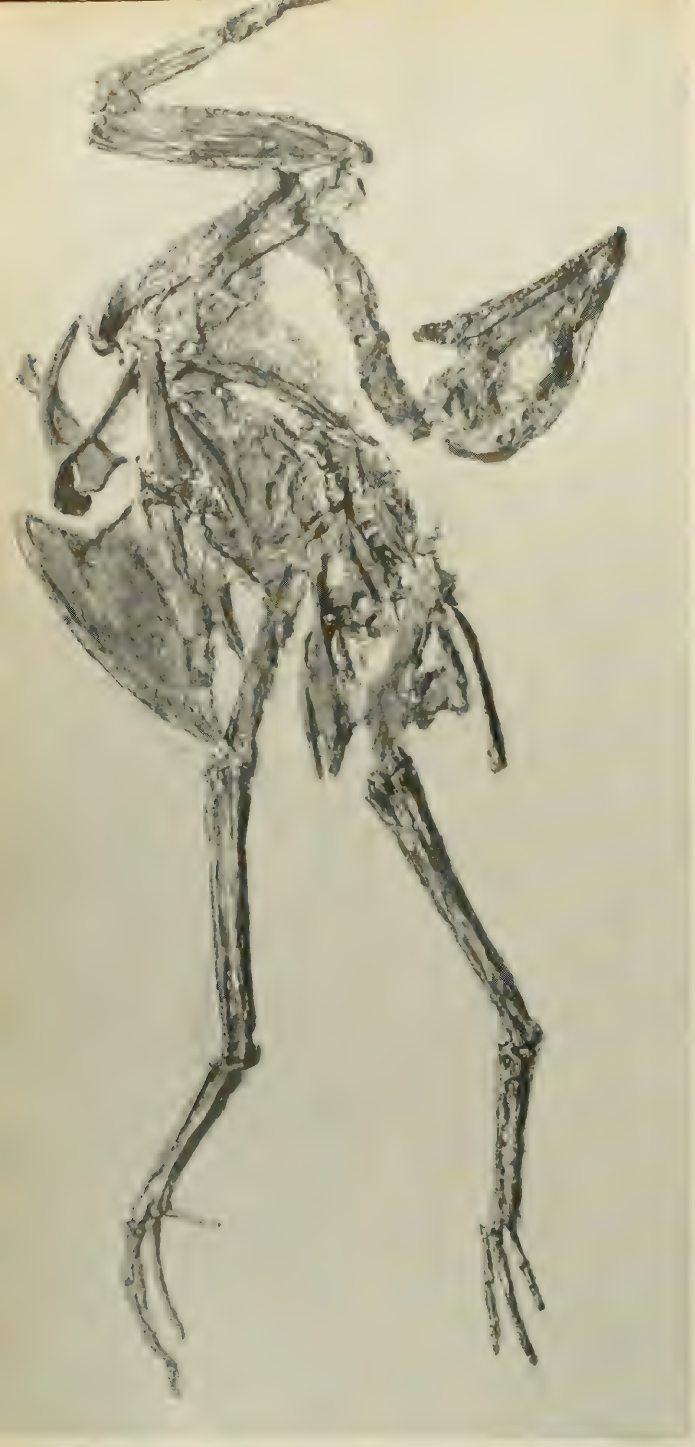
LARVAE are in the Syrphidae family, which has many genera of dipterous flies that live in decaying plants.



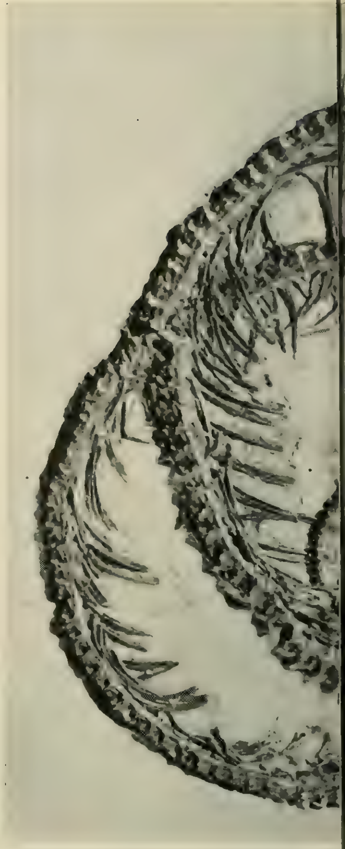
ANOTHER fly larva is, like the one above, shown here ×2. It may be that of a horsefly, a gadfly, or a deerfly.



CHAINS of conidia, in magnification of ×430, are from fungus that has a similarity to the living genus *Torula.*

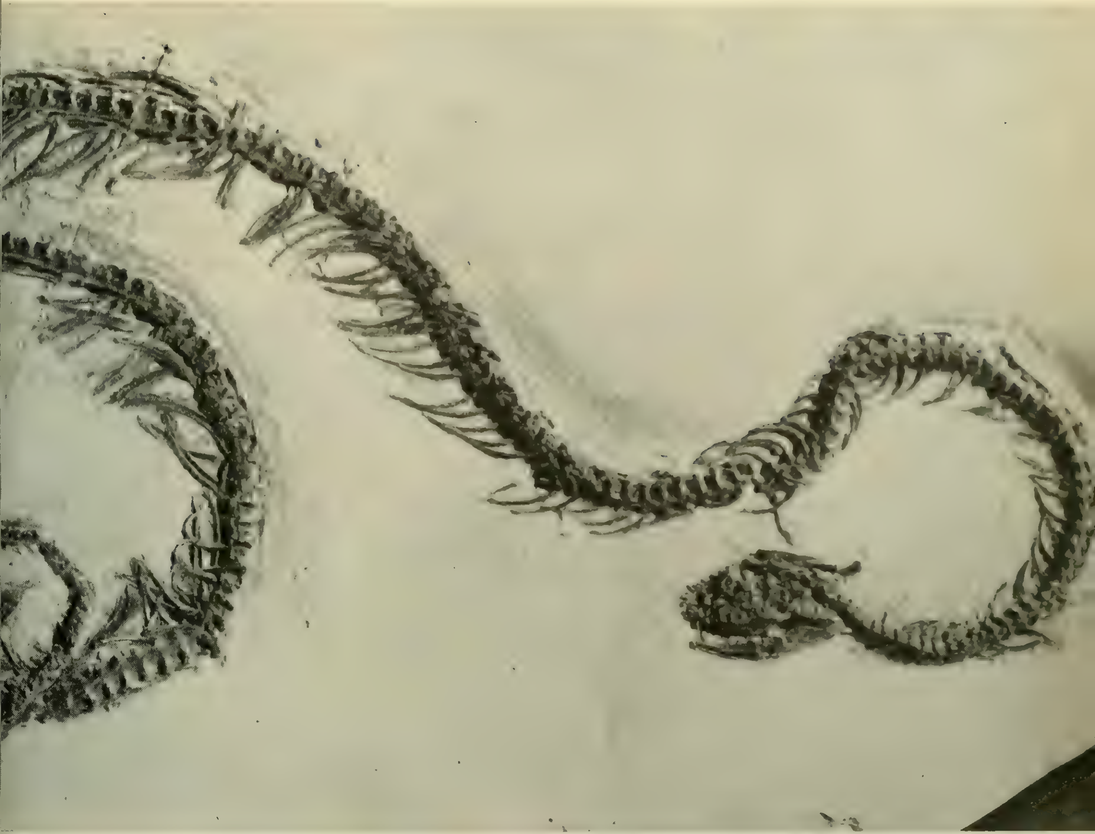


A **BIRD**, *Gallinuloides* sp., was once thought to be related to gallinules, but it is more similar to fowl-like chachalaca of the tropical Americas.



numbers of fishes in the Green River lakes remains a matter for speculation, although we do know today that such mortality might be caused by a rapid reduction of oxygen or by toxic substances produced by blue-green algae.

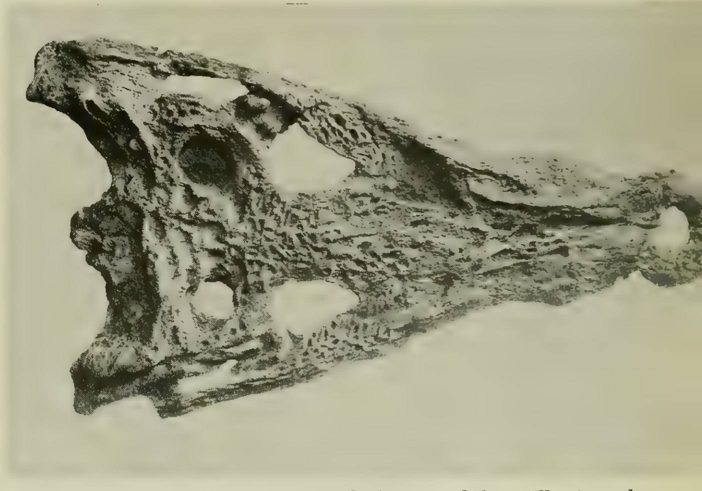
ALMOST as widespread, but never locally as abundant, are specimens of a fish called *Phareodus*. It belongs to the exclusively fresh-water family Osteoglossidae, which is now restricted to South America, Africa, Australia, Thailand, Sumatra, and Borneo. In Eocene times, however, the osteoglossids occurred in Europe as well as in North America. *Phareodus* seems to be most closely related to the living genus *Osteoglossum* of South America. Perhaps the most unexpected member of the Green River fish fauna is a form called *Notogoneus*. This genus belongs to the family Gonorhynchidae, which includes one living ge-



Most complete fossil snake found in North America is boa, *above,* which is 38 inches long. *Boavus idelmani* was found in the Fossil Basin area.

nus, *Gonorhynchus,* sometimes called the sandfish. It lives in coastal waters in the western Pacific, but its Tertiary relatives inhabited fresh waters in Europe and North America. *Gonorhynchus* and *Notogoneus* have small, ventrally situated mouths, indicating bottom feeding. *Notogoneus* has been found only in the deposits around Fossil and, curiously enough, in the Early Tertiary of France. The catfish *Ictalurus* existed in all of the Green River lakes. Pirate perches, represented by small fishes called *Erismatopterus,* are abundantly preserved in the deposits of Gosiute Lake. They differ in no significant way from the modern pirate perches that occur in the streams of eastern North America.

The true perches (Percidae) have probably been widely distributed over the Northern Hemisphere since the beginning of the Tertiary Period (Natural History, February, 1964). The



Skull of crocodile *Leidyosuchus* is 13 inches long, and its presence in the formation helps to illuminate the picture of these vast, ancient lakes.

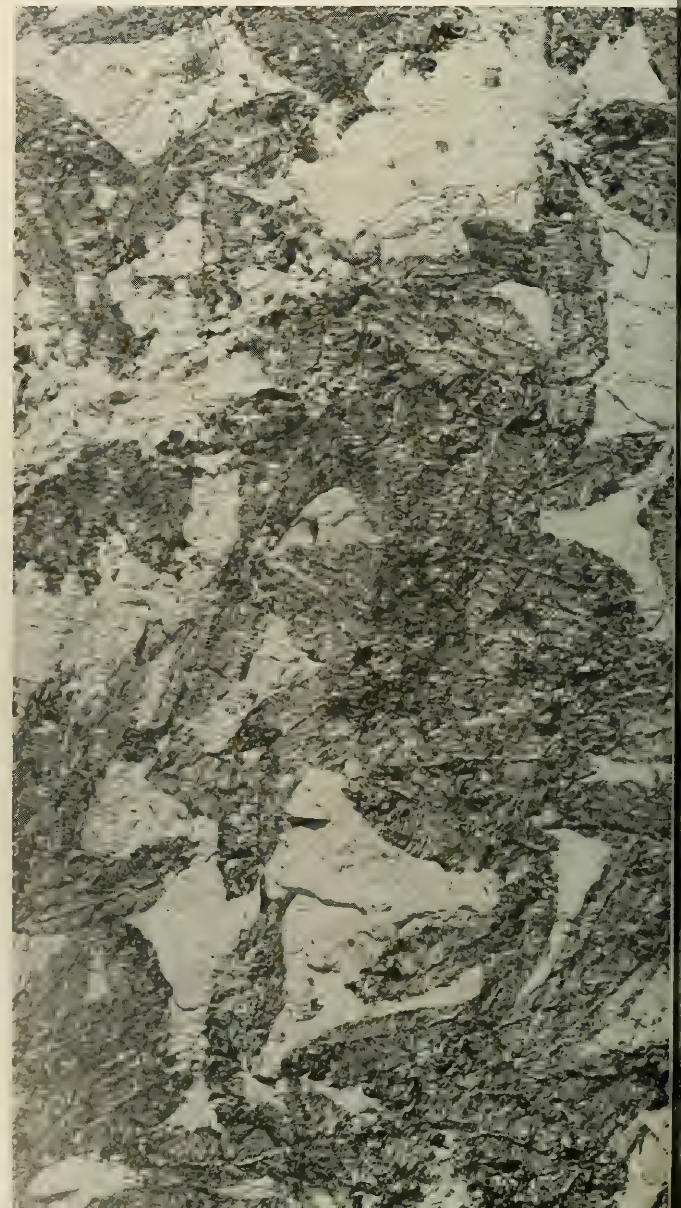
Green River representative of this well-known family is named *Mioplosus.* Its remains have been found abundantly around Fossil, but it probably lived in all of the Green River lakes.

The last member of the fauna is the spiny-rayed fish *Priscacara.* Although this genus has been assigned to various perchlike families, recent studies indicate that it belongs to the Serranidae, or basses. The basses have been widely distributed in marine waters since the Late Cretaceous and have probably invaded fresh water repeatedly.

THE Green River fishes are of particular interest for two reasons. First, they demonstrate that modern families and even genera, such as *Ictalurus,* were in existence by the Early Tertiary. This implies that teleosts must have become diversified rapidly during the Cretaceous, although we have little knowledge of where and how this radiation took place. Second, this fauna indicates that certain families inhabited a wider range of environment and had a wider geographical distribution than their living relatives. As pointed out earlier, the gonorhynchids are today exclusively marine and confined to the western Pacific. The osteoglossids now occur only in the Southern Hemisphere. The Green River lakes undoubtedly had some connection with the sea, possibly through a river system draining either into the Gulf of California or the Gulf of Mexico, and marine forms could have entered the lakes by this route.

The Green River fossils include not only representatives of plants and animals that actually lived in the lakes but also remains of terrestrial forms from surrounding land areas. In addition, the adjacent contemporaneous flood plain and stream channel deposits furnish further evidence on the life of the lake environment. Around the lakes and throughout the intermontane basins grew an almost continuous mixed forest. Upland trees, such as spruce, pine, and fir, are represented in the Green River beds primarily by pollen carried into the lakes by winds. Oak, poplar, maple, ash, beech, elm, and hickory grew on the lower slopes. Willow, laurel, and alder grew closer to shore, along with sago palms, hibiscus, and fig trees, which gave the region a semitropical aspect. The delicately preserved leaves of these trees are among the most beautiful of the Green River fossils. The ground beneath the trees was covered with a variety of ferns, mosses, liverworts, holly, viburnum, and lilac.

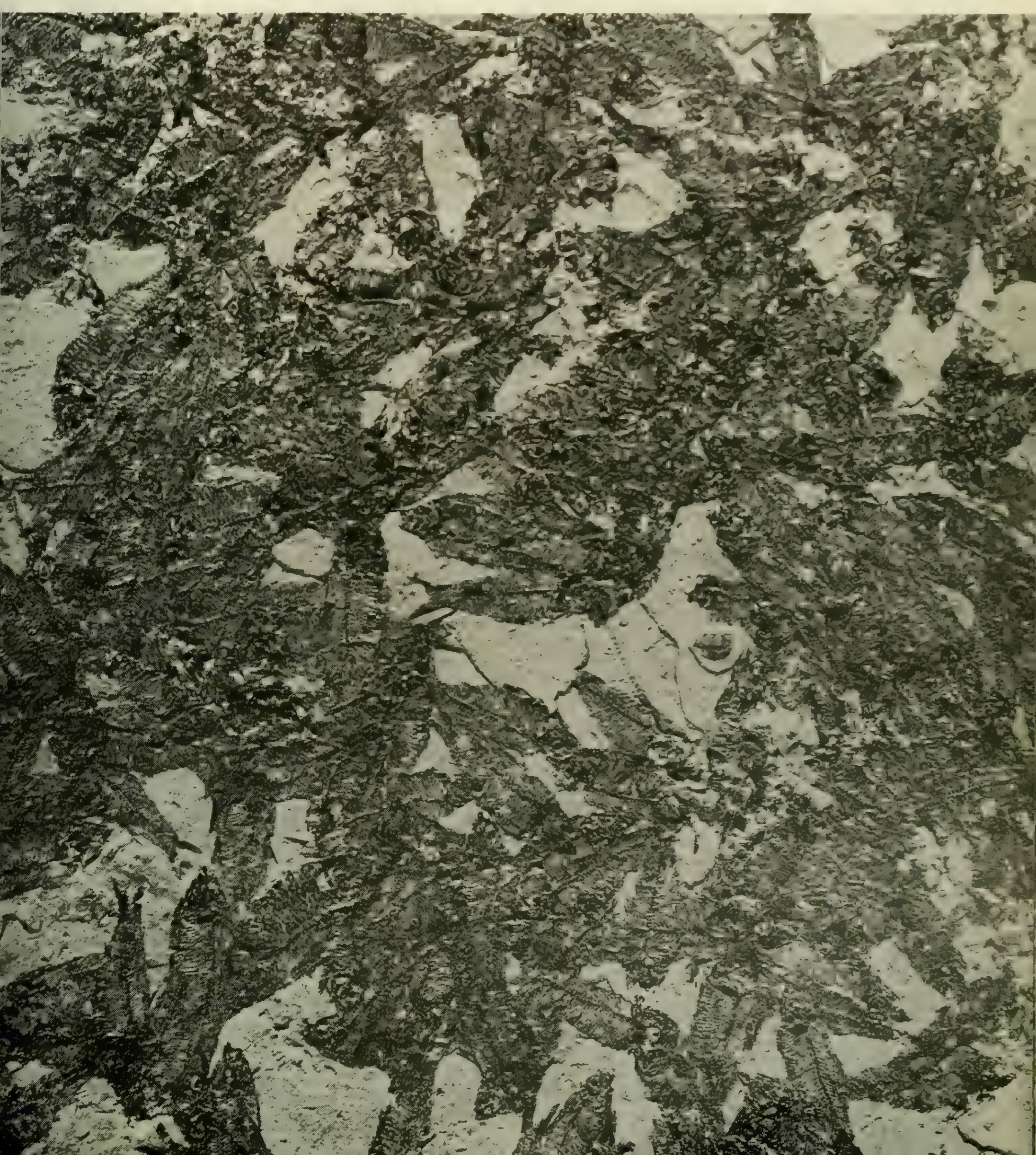
The animals that inhabited the lake shores were many and diverse. Amphibian remains have not been found in the Green River sediments, but they are known from the interfingering Bridger Formation. These include a toad whose living descendants are adapted for burrowing during dry periods. This again suggests long periods without rain. Crocodiles, such as *Leidyosuchus,* and several kinds of turtles also lived along the shores, where they basked on the mud flats. Birds



SINGLE, 3- by 4-foot bedding slab was covered with 300 herrings (*Knightia*), some of which are seen here. Reasons for this mass mortality are unknown.

must have been abundant and diversified; they are represented in the Green River by fossil feathers and a skeleton of the fowl-like *Gallinuloides*. Herbivorous mammals such as eohippus, primitive tapirs, rhinoceroses, and titanotheres browsed in the forests and open glades. A variety of archaic carnivores, up to the size of large wolves, preyed upon these ancient plant eaters. Squirrel-like rodents moved about in the trees together with early primates, while tiny insectivores scurried about on the forest floor. Several well-preserved bat skeletons have been found in recent years.

Today the motorist who travels through southwestern Wyoming or northeastern Utah will see the Green River Formation exposed in a series of rather monotonous rounded hills, occasional high cliffs and, especially in Utah, steep-walled canyons. Even from a distance the rocks of the formation can be recognized by their characteristic weathering pattern, their usually gray-buff color, and their banded appearance. To the traveler who is trying to reach Reno by nightfall, these rocks hold little interest, but to those who are willing to stop and look and perhaps be rewarded by a fossil leaf or fish, the past can come vividly to life.

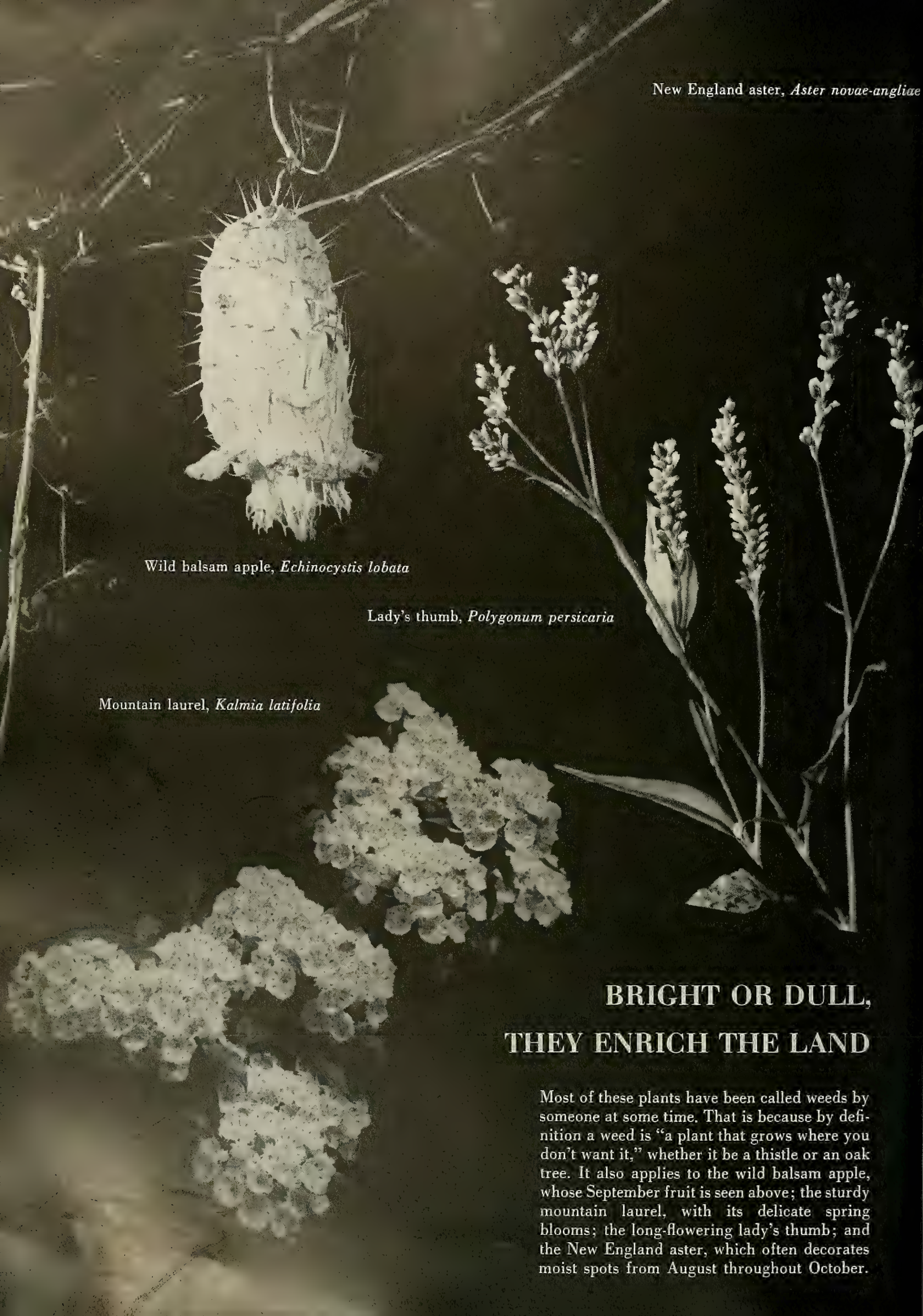


# A Weed Is Where You Find It

## AN INFINITE VARIETY OF FORM AND COLOR CAN BE FOUND IN WILDFLOWERS

A great portion of the New England states is covered with submarginal soil—a rocky land that defeated many early settlers and sent them West to open up more fertile farms. But in this soil—much of which is marshy, much acid—an incredible variety of wildflowers bloom from early spring until late autumn. The dull-white clusters of boneset (*Eupatorium perfoliatum*), *above*, are found in moist ground from July to September. The spectacular pink or white blossoms of the sometimes tree-size rhododendron (*Rhododendron maximum*) are usually at their peak in the damp northern mountains from about the middle of June into July, *right*.

Photographs by E. Javorsky



New England aster, *Aster novae-angliae*

Wild balsam apple, *Echinocystis lobata*

Lady's thumb, *Polygonum persicaria*

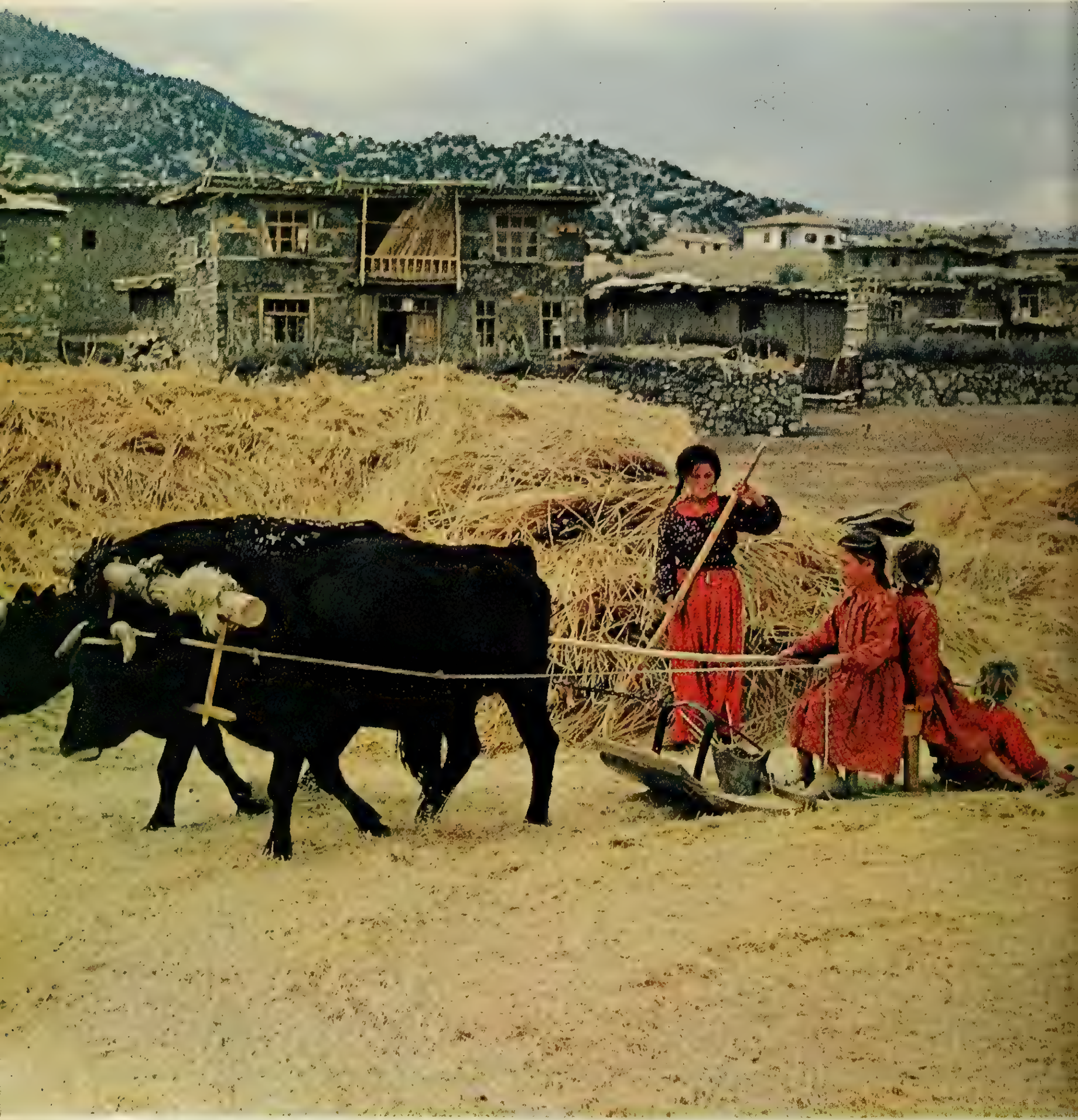
Mountain laurel, *Kalmia latifolia*

## BRIGHT OR DULL, THEY ENRICH THE LAND

Most of these plants have been called weeds by someone at some time. That is because by definition a weed is "a plant that grows where you don't want it," whether it be a thistle or an oak tree. It also applies to the wild balsam apple, whose September fruit is seen above; the sturdy mountain laurel, with its delicate spring blooms; the long-flowering lady's thumb; and the New England aster, which often decorates moist spots from August throughout October.

# The Threshing Sledge

## An ancient Turkish grain-separating method still proves efficient



[illegible] aid in harvest at small village of Suberde in the foothills [illegible] Taurus Mountains. Girl with fork spreads the wheat in front of *döven*, another drives, and two add their weight to the sledge as it threshes grain and chops stalks.

CHOPPED STALKS and chaff are carried to storage in wooden, V-shaped wagons.

By Jacques Bordaz

Until the development of metallurgy, man depended on stone to make his tools and weapons. Of all the types of stone used by early man, flint was preferred because it was extremely hard, and yet it could be easily knapped. So important was it, that early man's technological progress can be measured by his ability to manufacture flint tools without waste. In Late Paleolithic times, skillful manufacture of smaller and lighter tools made it possible for man to extend his hunting range far from his flint sources. Even after man had begun to farm, flint was used until metal tools became common.

However, flint was never completely abandoned. It was used over a large section of Eurasia as "strike-a-light." Oddly enough, in this capacity it became an essential material from the sixteenth to the nineteenth century, concurrent with the development of firearms. When percussion caps and friction matches were invented, the importance of flint seemed to have ended. Except for its use by a few primitive societies in marginal areas of the world, one would think that today flint would interest only archeologists, collectors of antique firearms, and a few modern knappers, who still make stone artifacts for fun or profit.

Therefore I was surprised to learn, during the course of my archeological field work in Turkey, that flint was still an important material for many Turkish farmers who use it most efficiently for food production. Thus, the farmers who worked with us on a Neolithic site, rich in flint artifacts, would leave at the end of the day to thresh their newly harvested wheat with flint-studded sledges.

Since about 7,000 B.C., when wheat was first domesticated in the Near East, man has searched for efficient methods for separating the grains from the rest of the plant. It is relatively easy to separate the whole spikes from the stalks and to break them into pieces by beating them with sticks. But the husks, especially those of primitive varieties of wheat, tend to hold the grain tenaciously.

Probably the earliest solution to the problem was to parch the wheat ears. One example of a simple parching method could be observed in Scotland as late as the eighteenth century. The ears of wheat, still attached to the stalks, were held over a flame, and the grains were beaten off with a stick the instant the husks were burned. Ovens could have been used to "pop" the grain. At the site of Jarmo in northern Iraq, where the first evidence for wheat domestication was found (NATURAL HISTORY, October, 1964), there were domed mud ovens, which might have been used for the purpose. These methods may have burned the grain—fortunately for the archeologist. Accidents during parching, or while drying the grain in kilns, have yielded large quantities of well-preserved, carbonized grains that contribute to our knowledge of ancient agriculture. There is evidence that even the very early farmers selected those varieties of wheat that were easiest to separate from the husks. At the same time, other methods that did not involve the use of fire were developed for the separation of grain from husk.

The alternative to parching is one of three basic threshing methods—beating, treading, or sledging. The use of sticks to thresh wheat is obviously of great antiquity, and was widespread. A much more efficient beating implement, the two-piece flail, was probably invented in Gaul, but not until the fourth century A.D., and came into common use in Europe during the Middle Ages. It continued to be the most important threshing implement in Europe until the beginning of the nineteenth century, when it was slowly replaced by machines—at first essentially mechanized, multiple flails.

The second basic method—treading—was developed in the Mediterranean area and in the Near East, where it is still used in some places today. The wheat is spread in a circle over the hard-beaten earth of the threshing area. Donkeys, cattle, or horses are driven continuously around the circle until their hoofs have freed the grain from the husks. This method is often illustrated in the art of ancient Egypt, where it was the prevalent threshing method. Treading is remarkably fast and efficient when many animals can be used simultaneously. This method probably was not used in northern Europe, because unlike flailing, which can be done under cover, it leaves the wheat exposed to rain damage in those countries that lack an extended dry season.

The third and most complex method—sledging—was also developed and widely used in the countries of the Mediterranean and the Near East. The two most important implements used are the Carthaginian cart (*plostellum poenicum*) and the threshing sledge. The *plostellum* — basically a heavy wooden frame resembling a sled—is described in the Roman literature as early as the first century B.C., and owes its name to the toothed wheels or rollers that are used to thresh the wheat. These are studded with metal teeth and are set on two or three axles placed between the runners. Cattle or horses are used to pull the *plostellum*, and there is a seat for the driver, mounted on the runners just over the axles. The *plostellum* was widely used in Tunisia, eastern Spain, and Egypt,

**DUNG is carefully collected during the threshing and is later burned as fuel.**

and is still used extensively in eastern Turkey and central Iran.

The true threshing sledge is of even greater antiquity. It is of simpler construction than the *plostellum,* made essentially of heavy, flat boards that curve upward at the front. Numerous stone fragments, usually flint, are set into the underside. The sledge is pulled by animals and the driver stands—or sometimes sits—on a chair placed directly on the boards.

THIS sledge is well known by its Roman name of *tribulum,* but much earlier references are made to it. For example, in the Old Testament (Oxford Annotated Bible, Revised Standard Edition 1962), in Isaiah (41:15), which is probably from the eighth century B.C., it was reported that God had told Israel that He would make her strong in these words: "Behold, I will make of you a threshing sledge, new, sharp, and having teeth; you shall thresh the mountains and crush them, and you shall make the hills like chaff. . . ."

The *tribulum* was especially popular in northern Spain, Greece, Palestine, Syria, Cyprus, and Turkey, but it does not seem to have been much used in temperate Europe, probably for the same climatic reasons that discouraged treading. Neverthless, it has survived in the English language as the root of the word "tribulation."

In the Pisidian lakes region of southwestern Turkey, where I had the opportunity to observe the use of the *tribulum,* it is usually referred to as a *döven.* It is about six feet long and two and a half feet wide and is made by using two or three rectangular crosspieces to join two parallel, hewn planks. The planks are two and a half inches thick and narrow slightly in the front, which gives the *döven* a trapezoidal shape. The front of the sledge is hewn into an upward curve, and the area of the flat underside is often planed so it is thicker at the back than at the front. In this flat area—about two-thirds of the entire length—are chiseled six to eight hundred parallel, wedge-shaped slots, one to three inches long. Each board has twenty to twenty-three rows of thirteen to eighteen slots, which are usually arranged in diagonal rows or in a herringbone pattern pointing to the front. The slots hold flints that are knapped in triangular or rectangular flakes, two to four inches long. They are shipped south in canvas bags from the Kütahya and Eskisehir regions to carpenters who specialize in the manufacture of *döven,* and to hardware stores that supply farmers with repair materials.

Pairs of animals are hitched to the sledge. When cattle are used, a chain on the yoke is attached to a hook on the front crosspiece. Horses, which sometimes are used singly, are harnessed by traces to a swingletree that is linked to a vertical wooden peg attached to the *döven.*

Each farmer brings his harvest to his own section of a communal threshing area on the outskirts of the village —an area chosen for its proper exposure to the wind, an essential in winnowing. The wheat is spread in a circle one foot thick and about forty feet in diameter. One man drives the *döven* in a circle over the wheat, and another continually turns it with a wooden fork until all of the grain has been separated and the stalks chopped into very small pieces. The threshed wheat is carried outside the circle, heaped into rectangular mounds, and winnowed. Because the grain is the heaviest part, it falls to the ground almost immediately; the chaff and the chopped stalks are carried some distance away by the wind. The grain is

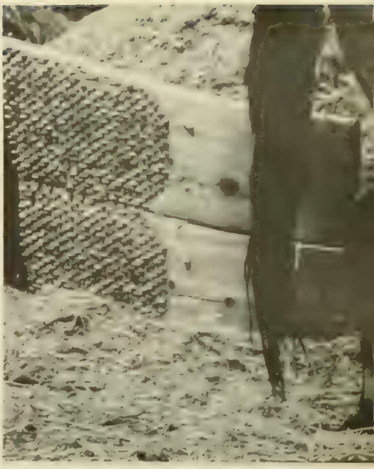
**REED HUTS at every family site dot the communal threshing area, *right.***

packed into canvas bags after being sifted through round, fine-meshed screens to remove earth and other debris. Each farmer piles his chopped stalks and chaff into rectangular heaps, which he carts to the village and stores.

This chopped straw has several uses—as a fodder during the winter, mixed with dung for fuel, and mixed with mud to make bricks or to cover walls. Its importance to the farmer explains, in part, the continuing popularity of the threshing sledge, which, in one operation, provides him with two vital products. In other methods the farmer must chop the stalks separately.

It is known that treading with many animals is faster than threshing with a sledge, and probably destroys less grain. On the other hand, in order for treading to be efficient, many animals must be used during harvesttime when they are in most demand for other purposes. Furthermore, one or more experienced men are needed to handle a large number of unharnessed animals simultaneously. Those men could be better used in the harvesting and carting. In contrast, sledging is a simple task, especially with cattle. It is generally carried out by old people and even by young children, who obviously enjoy the work and are also able to contribute to harvest activities.

Since cattle were the first domesticated animals able to pull a threshing sledge, one may date its first use close to the time of the first evidence of cattle domestication—that is, perhaps as early as 7,000 years ago. The ancient threshing sledge will very likely remain an efficient grain-threshing and stalk-chopping implement for many farmers of the Mediterranean lands and the Near East until mechanized agriculture becomes more prevalent.



CHIPPED FLINTS in bottom of sledge are worn smooth from continual use.

# Nesting of the Wood Stork

## Unusual Florida site aids in observation

By George Heinzman
and Dorotha Heinzman

**These storks** chose an unconventional nesting area—the tops of dead oaks.

Four of the seventeen species of storks of the world are called wood storks. The one native to the United States is *Mycteria americana*, of the family Ciconiidae, which is still often called the wood ibis. This bird is also known locally as flinthead, ironhead, and gourdhead—names descriptive of its heavy bill and the rough, black skin of its head and neck.

Few details about the habits of the wood stork existed until recent years, when Philip Kahl, Jr., Alexander Sprunt IV, and the late Robert Porter Allen undertook studies in Florida for the National Audubon Society. Our studies, with the Florida Audubon Society, were made in central Florida.

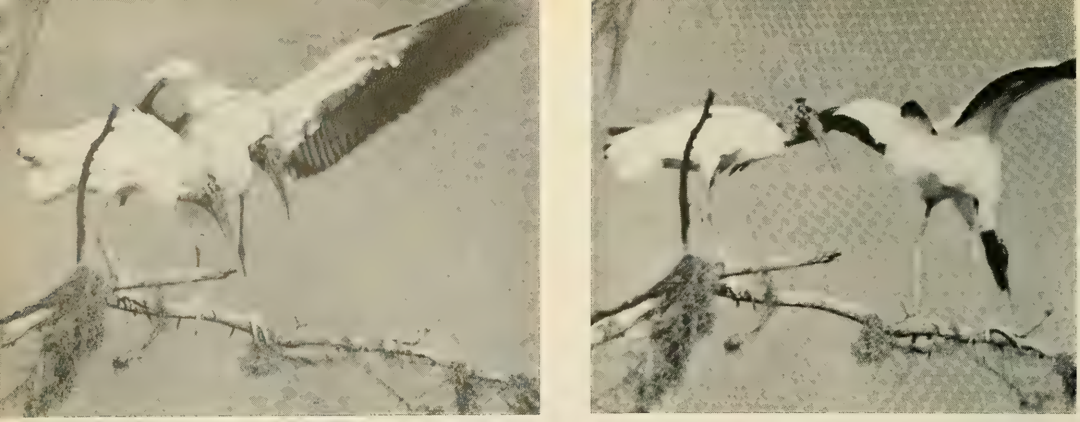
The wood stork, which nests in colonies and is usually found in groups throughout the year, prefers an environment of wooded swamps surrounded by broad marshes. At one time the bird ranged through most of the southeastern United States, west to Texas, and south through Mexico into South America, but its known breeding range within the United States is now limited to Florida—although there are migratory wanderings in other states. The fourteen known wood stork colonies in Florida can be divided roughly into two breeding populations—those in south Florida, which nest through the winter months, and those in central Florida, which begin later but overlap in time and nest on through the spring months.

**Although** graceful in flight, wood stork is awkward and clumsy on foot.

The handsome wood stork is 3 to 3½ feet tall, has a wingspread of about 5½ feet, and weighs 6 to 10 pounds. Its white plumage is broken by the iridescent black flight and tail feathers with green and purple hues. There is no visible difference between the plumage of the sexes. During the breeding season, the white undertail coverts become plumelike, and a pale, pinkish cast appears under the wings.

The birds' dark legs are sometimes so covered with excreta that they appear chalky. Its heavy bill, which is bright yellow in nestlings and dark in the adult, equips the bird for a groping type of feeding rather than for the stabbing type that is typical of herons (Natural History, June, 1962). It gropes in shallow water, senses the food matter, and clamps its bill shut. Foot stirring and wing movements, used in conjunction, probably startle small fish and crustaceans into conspicuous activity.

Although its flapping flight appears heavy at low elevations, the stork soars effortlessly once it is aloft. To



**Courtship**, which includes bill clapping, wing flapping, head shaking, and posturing, immediately precedes and also continues during the stork's nest-building period. Within a week after arriving at rookery, female lays her first egg.

reach distant feeding grounds, it often soars high on rising columns of warm air and lines out in a slanting glide.

During the 1960 to 1961 breeding season, one of the central Florida colonies provided us a unique opportunity for observation. Ancestral breeding grounds at Panther Point in Polk County had been converted into a settling basin for water drainage from phosphate mining, and the trees died as the sludge slowly rose around them. The storks, however, moving from cypress to oaks, refused to leave the area. The sludge finally rose to a point just below the birds nesting in the upper branches of the trees, and provided us with an excellent opportunity to take photographs from a boat.

Late in February the storks began to congregate at the breeding grounds. By mid-March, we estimated 400 birds to be present, and at the high point—mid-April—more than 1,000 storks inhabited the colony. On May 28, some 288 nests were still in use, and the last young fledged in late July. We estimated that during the entire season, which extended over a five-month period, there were about 400 active nests in the colony, and that most of them produced two to four young.

The wood stork's courtship involves a mixture of hostility and sexual behavior—a not-unusual pattern in birds (Natural History, April, 1964). Once pairing begins, it proceeds rapidly. Bill clapping, wing flapping, head shaking, and posturing form part of the ritual. The flimsy nest, a comparatively small platform for such a large bird, measures 30 to 36 inches in diameter and is constructed of sticks, twigs, Spanish moss, and, almost invariably, freshly added green leaves. It is built, and the first egg is laid, within a week after copulation, and nest repair continues until the young are fledged.

Dull white eggs are laid at intervals of one to three or more days, and incubation begins at once. Both adult birds participate in incubation, which has been estimated as lasting about 32 days. Often the mate of the bird on duty stands by for long periods. At other times, it forages for food. A bowing ceremony and billing accompany its return to relieve the mate on the nest.

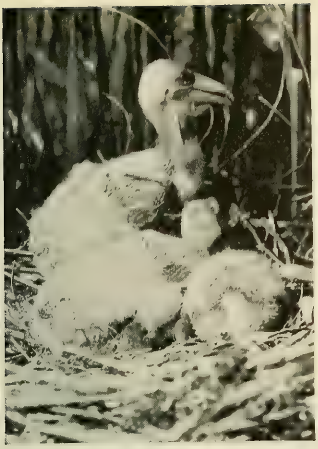
The young, unlike those of many birds, do not hatch at approximately the same time; they may emerge several days apart. Some observers have pointed out that this could well be one means of perpetuating the species. In years of plentiful food supply, all nestlings may live, but in lean years the oldest, and hence the strongest, will get their fill first, while the younger, weaker nestlings may starve. In this manner, at least a portion of the year's young will be salvaged, while if all nestlings had been the same size, all might have died.

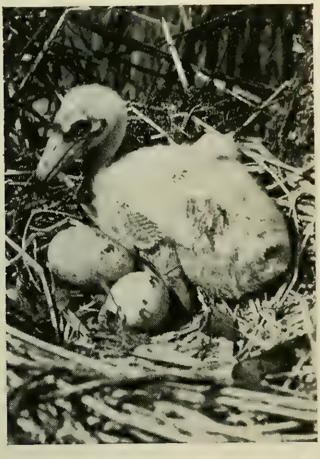
The newly hatched wood stork requires constant protection from the extremes of weather. Its first few days are highly critical. Direct exposure of its nearly naked skin for more than a very few minutes could prove fatal, and its rapid growth rate requires many feedings. Thus, one parent bird must remain on the nest while the other makes trips to the feeding grounds. On hot days, we have often seen storks stand for hours, shading their nests with half-opened wings.

The parents regurgitate food into the nest, and the young retrieve it. At first, the food is partially predigested in this manner, although a little later, small fish are deposited almost intact. Toward the end of the nesting period, we have seen fish up to ten inches long brought to the young.

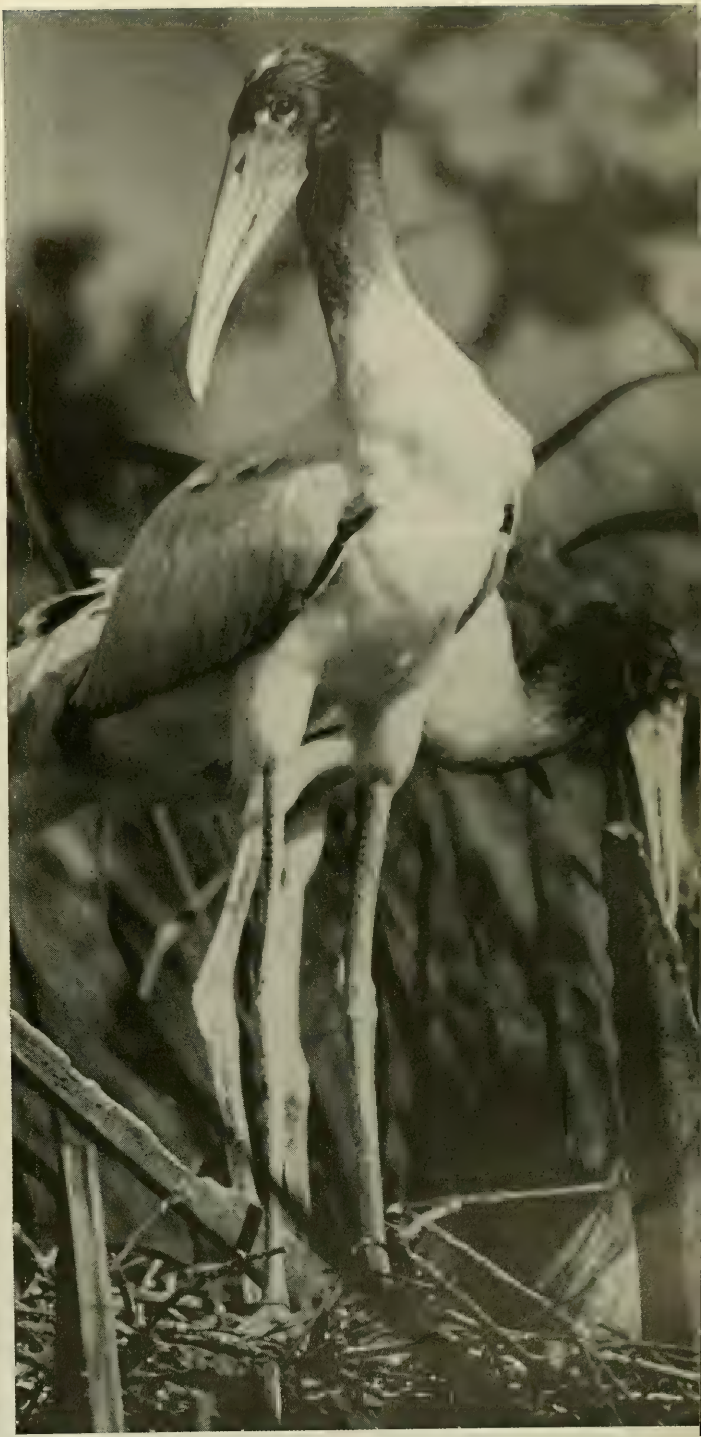
Within ten days a white, woolly down begins to form, and in two weeks the nestling is covered. (We believe the accompanying photographs of nestling wood storks under two weeks of age are the first to be made under natural conditions.) At the age of about three weeks, black begins to show against the white down on the primaries, and the young begin to stand. Wing exercise begins and increases until the birds leave the nest. By the sixth week, a striking black-and-white plumage pattern is well developed, and the head and neck feathers begin to turn a smoky gray.

By the eighth week the nestling is nearly as large as its parents. It practices flying, flapping its wings strenuously and hopping into the air. With three or four large youngsters on such a comparatively small nest, conditions become very crowded, and each bird must wait its turn at exercise. The nestlings are noisy, while adults are apparently almost voiceless, their sounds largely limited to hissing and a resounding bill clapping. When the young are fully fledged, at about 60 to 65 days, they have attained adult-size, although they will retain the gray plumage on head and neck until adult-

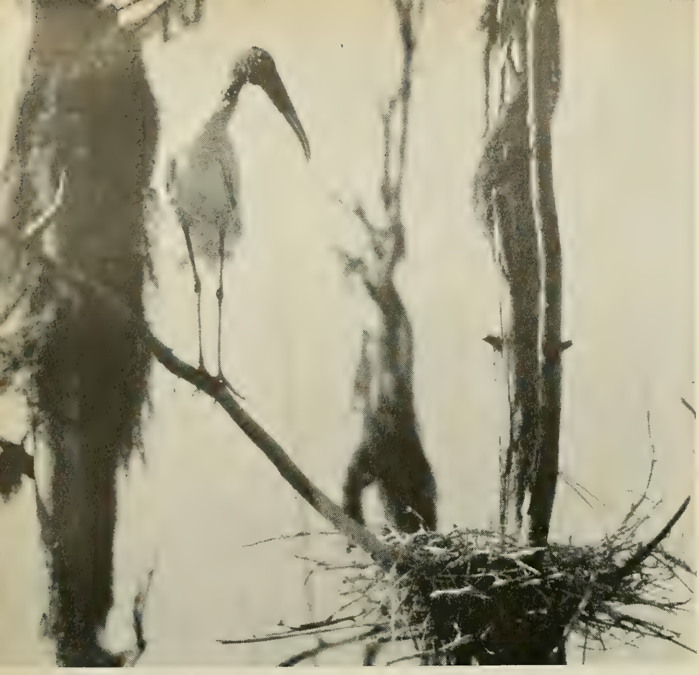




TIME LAPSE in hatching is shown by three nestlings 7 to 11 days old (top); 12-day-old beside unhatched eggs; and 3-week-old towering over 1-week-old.



AT 6 WEEKS, plumage pattern is well developed. Head and neck are now gray.



**Typical** wood stork nest is flimsy, shallow, and quickly built. Repair continues through season, and birds often rob sticks from another nest.

hood, probably about the third year.

The stork's first flights are short and are limited to the limbs immediately surrounding the nest. Gradually the flights become longer—from tree to tree in the colony, and finally to areas outside the colony. During the intensive feeding period, the adults we observed seemed to forage at more distant feeding grounds, leaving nearby grounds virtually untouched. Later, although the parents continued to bring food to the nest for a few days, the newly fledged young visited these closer grounds and collected a portion of their own food.

Immature birds often form flocks, flying and feeding by themselves and mingling with adults only at the colony. Shortly, however, the colony begins to thin out, and within a month or so after the last young have flown, the birds begin their summer wanderings. At this stage, we have seen small bands of immatures in shallow, marshy waters far from any colony, with no adults nearby.

After the nesting season, wood storks wander generally north and northwest in more of a dispersal than a true migration pattern. Possibly depending on food abundance, these wanderings may reach, although rarely, the northeastern and far western states. Then, as the breeding season approaches, the birds again congregate in the colony's general vicinity.

What triggers the breeding season is not clearly understood. The difference in starting dates between colonies in south Florida and those in central Florida is so great that it is unlikely that temperature or light are governing factors. Food availability seems important, however, because a large stork colony requires literally tons of food during a season. The National Audubon Society has estimated that up to 50 pounds of food are required for each nestling wood stork. Thus, 12,000 young storks, which might be raised in one colony such as Corkscrew Swamp Sanctuary, require 300 tons of food, mostly fish. This figure is for nestlings alone, and does not include adult bird requirements. Probably the total consumption at the small colony at Panther Point would approximate 50 tons.

One theory of food availability, developed by Philip Kahl, Jr., is based on water level. In comparatively flat Florida, heavy rains can more than double the water surface and cause a wide dispersal of food. But when the food concentrates in smaller areas as a result of falling water levels, it is more readily available to the birds. Extreme drought, on the other hand, so dries the marshes that food is greatly reduced. Another factor, we believe, may be the formation of favorable air currents that enable the stork to range farther in search of food. If rising columns of thermal air allow the bird to double its feeding radius, the feeding area is quadrupled while the bird expends very little additional energy. Most days during the nesting season—in central Florida, at least—are favorable to the formation of these currents, and perhaps breeding begins partially as a result of these. After a cold night, there may be as much as a 40- to 50-degree temperature rise from dawn to noon at ground level, causing fast-rising columns of air. We have seen some birds seek such a thermal current and rise in minutes to an estimated height of a mile without moving a wing.

The wood stork has had a long history of decline, brought about more by destruction of habitat than by any other single factor. Timber cutting and marsh drainage have reduced the stork population's preferred environment. The 1961 to 1962 season was a notable failure. While three stork colonies in the mangroves of Everglades National Park were active, those in the "big cypress" of south Florida and those in central Florida were non-productive. Birds appeared at or near some of the colonies but did not nest, while at other colonies, no birds appeared. The decrease was attributed to limited feeding facilities because of drought. Most of these colonies became active the following season, 1962 to 1963, and we located a new one in central Florida that replaced one small colony that was lost. At the Panther Point colony that year the birds returned to find trees in the area deeply submerged in sludge, with their protruding tops rotten and crumbling. As a result, the storks nested in live trees about a mile away.

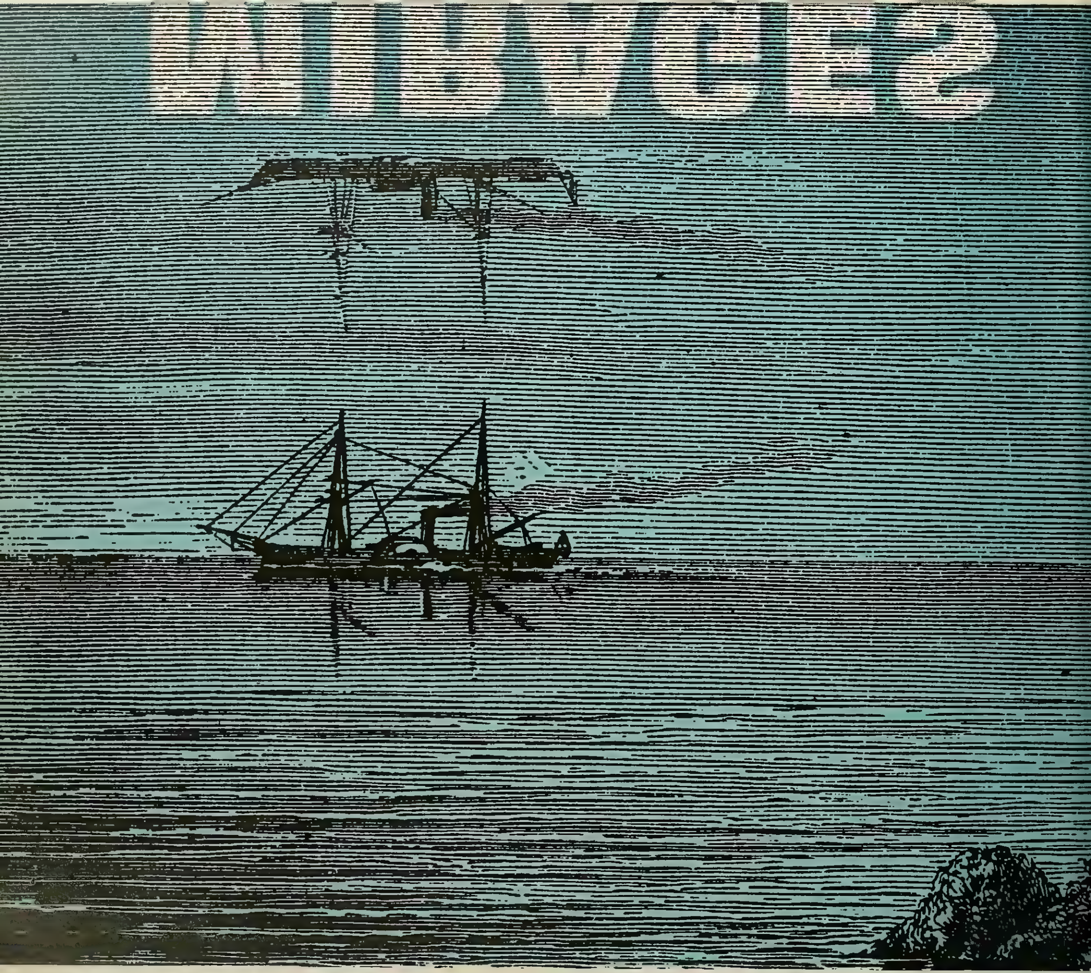
Although three of the past four nesting seasons have been successful, the wood stork is currently in a precarious position. Its future in the United States hinges upon man's conservation of its remaining habitat. Land drainage and timber destruction continue at a stepped-up pace in Florida, effectively destroying the major factors of the wood stork's ecology—trees to accommodate nests near marshes large enough to provide food.

The National Audubon Society owns and protects Corkscrew Swamp Sanctuary, the largest remaining stork colony, and three other colonies receive protection in Everglades National Park. The Florida Audubon Society has co-operated with private landowners to make sanctuaries of three more colonies. These and other co-operative efforts may mean the difference between the survival and the extinction of our only native stork.

**Wood storks** normally nest high in the tops of live bald cypress trees.

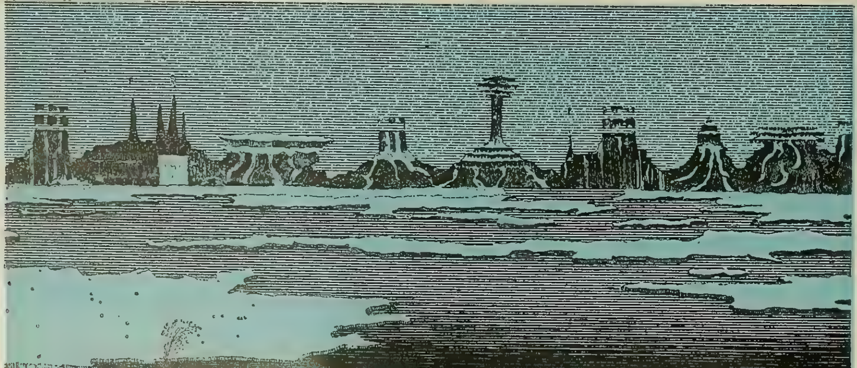
**Nest** of four is crowded before the birds take flight at about 65 days.

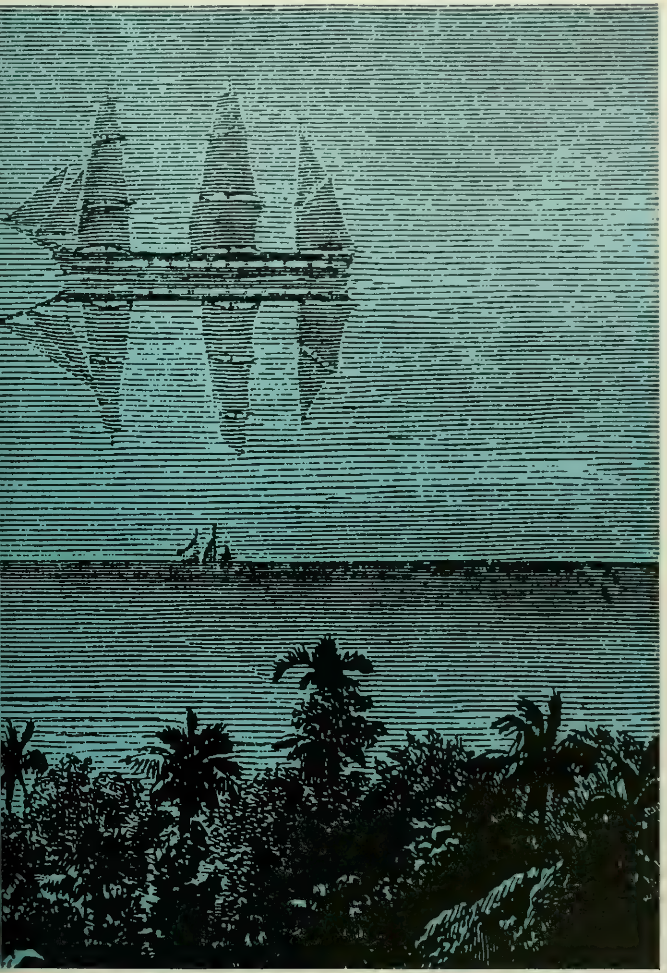
# MIRAGES



*Inverted and enlarged mirages, caused by air temperature differences, occur at sea.*

*Artist's rendition of "looming," on Greenland's east coast, was published in 1821.*





# Curved light rays create images in the sky

By David Linton

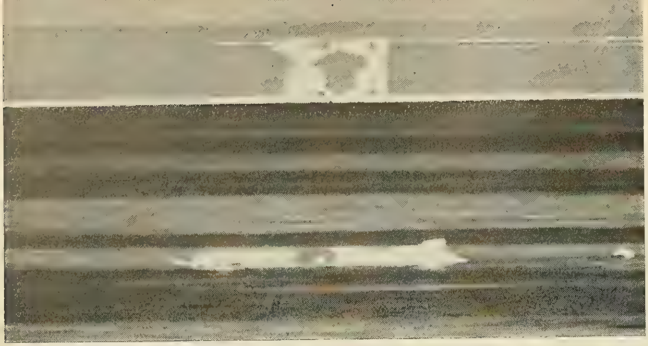
Mirages, often portrayed as hallucinations caused by extreme thirst, are actually just as real as images seen through a telescope, and both are produced by a bending of light rays. In a telescope, rays of light coming from an object are bent by glass lenses before they reach one's eyes. In a mirage, they are bent in much the same way by layers of hot and cold air.

The most common mirage is the shiny "wet" patch that appears far ahead on a highway but disappears as it is approached. Often blue in color, this mirage is an image of the sky. It glistens on the highway because the sun striking the pavement heats the layer of air nearest the road, causing it to expand and become thinner. This layer of thin air is topped by a layer of heavier air, and the normally thinner air is then on top of that. (Ordinarily, the atmosphere near the earth is dense and becomes thinner at higher altitudes.) It is this giant sandwich, or "temperature inversion," that can bend light rays in much the same way water in a bucket seems to bend a stick projecting from it. The path of light that carries the image of the stick to one's eyes is straight until it reaches the water, a denser medium, and then it continues at a different angle.

Light will also be bent in the atmosphere, although the change in density from one layer of air to another is less abrupt than the change in density from air to water. When one sees a "lake" on the highway, the light reaching one's eyes has actually traveled in a long curve through layers of varying air density from the sky, and what is seen is not the highway, but the sky. In the same way, the light from a rising or setting sun is so refracted by the atmosphere that when one sees the sun at the horizon, it is actually below it. For this reason, astronomical observations must be corrected for refraction.

Because mirages depend on large temperature differences in the air, they occur most often in places where temperature ranges are extreme—in deserts and polar regions. Deserts can be very cold at night and very hot in the day, and lakes often appear in the desert just as they do on a highway. During summer months in the polar regions, when there is almost continuous sun, the land warms quickly, while the sea stays cold much longer. When warm air from the land forms a layer above the cold air from the sea, inverted or enlarged mirages may occur above the surface of the sea.

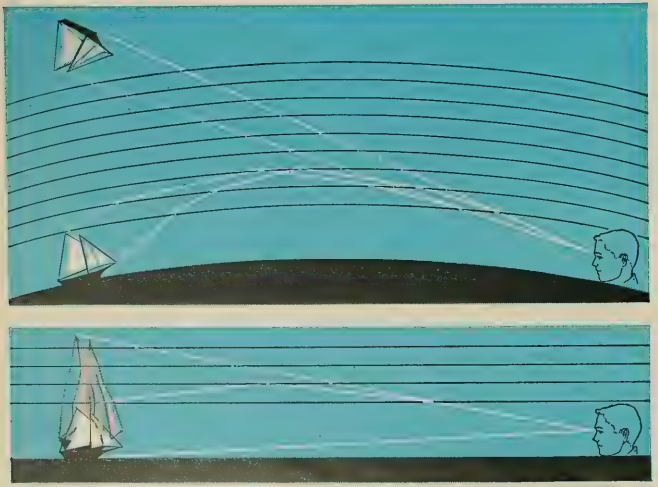
Inverted images of ships, islands, or icebergs may be seen in the spring along the seacoast in the polar regions. The optical effect is similar to the inverted image of an object that one views through a camera. Sometimes, depending on the refractive index of each layer of air, the real object is vis-



*Iceberg, inside gray haze, appears doubled. Thin white line near top is inverted mirage of the lower, apparently solid, white line—actually floating pieces of ice.*

ible, right side up, and the inverted image just touches it at the top. A lighthouse in the Strait of Belle Isle, between Newfoundland and Labrador, is often seen "double" in this way. At other times the object itself is over the horizon (*see diagram below*), and only the upside-down image may be seen. The crew of a Canadian government supply ship on a summer voyage in Hudson Strait once saw a sailing ship upside down in the sky. The image was so clear, they reported, that they could see the ropes in the rigging and sailors walking about the deck. Later in the summer they encountered the actual ship, and a comparison of the ships' logs showed that they had been 75 miles apart when the mirage occurred. The inverted mirage takes place occasionally in the desert, too, causing towns or oases to appear in the distance when they are actually over the horizon many miles away. The stories of travelers having been fooled by these mirages are largely fictitious; only a very confused and exhausted traveler could fail to notice that the buildings and palm trees were upside down!

A more common, though less spectacular, type of mirage often seen at sea is the enlarged mirage, a phenomenon known as "looming," in which objects are greatly magnified in height and occasionally in width. When the object is viewed through horizontal layers of air of varying density, the layers act as a lens, magnifying the object in a vertical direction. If the atmosphere is likewise vertically stratified, the object will be magnified in width as well. In Europe this effect is called the fata morgana, after a mirage that recurs frequently across the Strait of Messina, which separates Sicily from the Italian mainland. From across the Strait, the opposite shore seems to be stretched upward, and everything on it is magnified. The effect was named the fata morgana as it was originally thought to be the work of Morgan le Fay, legendary sister of King Arthur. *Fata* is fairy in Italian.



*Light rays, bent by air layers of varying density, can either produce an inverted image, as at the top, or create the effect of "looming," as seen in lower sketch.*

Looming can occur almost anywhere along the seacoast. A band or layer of slight haze forms along the horizon and whatever is within that layer will seem to have been stretched upward. Ships and islands appear taller than normal and often seem to float just above the sea's surface.

Inverted and elongated mirages will sometimes appear together. The stretched image will be surmounted by an inverted image, and on rare occasions, several images will appear one on top of the other, alternately right side up and upside down. An inferior mirage, in which the image of an elevated object (usually a cliff or headland) is seen inverted and *below* the real object, is even rarer.

Mirages rarely remain unchanged for long. A slight breeze or warming by the sun is enough to dissipate them, and they seldom seem completely clear. A mirage can be seen from one viewpoint, but not from others, and it is not uncommon for the helmsman of a ship to see an "island" while the lookout in the crow's nest sees nothing. The mirage will move and change if the observer moves, and it is never possible to get close to it. This explains old sailors' stories about uncharted islands that are sighted from time to time but always disappear or recede when approached. Lucian of Samosata (A.D. 120-180) mentions one, called the Isle of Dreams, in his *True History*. Columbus writes in his diary that the inhabitants of two islands in the Canaries told him that every year at a certain season they saw an island to the west. They had sent several expeditions to look for it, but it always disappeared.

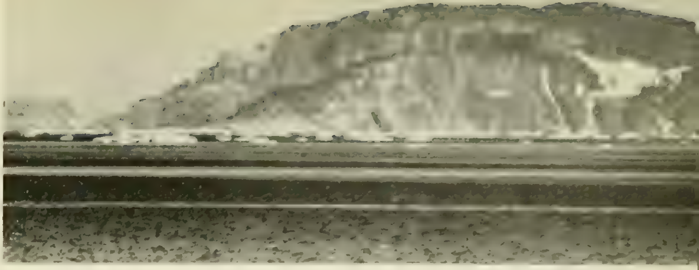
Elusive as they are, however, mirages are not always unpredictable. Because of local weather and ocean conditions, there are places where they occur fairly regularly. The Strait of Messina is one of these, and the coast of Labrador is another (*see photo-*

*graphs at right*). The cold Labrador Current comes down from the Arctic carrying a mass of floating ice about one hundred thousand square miles in area. In summer the temperature of this water is still near freezing, but a few miles inland from the coast, the air temperature may be in the eighties or occasionally even higher.

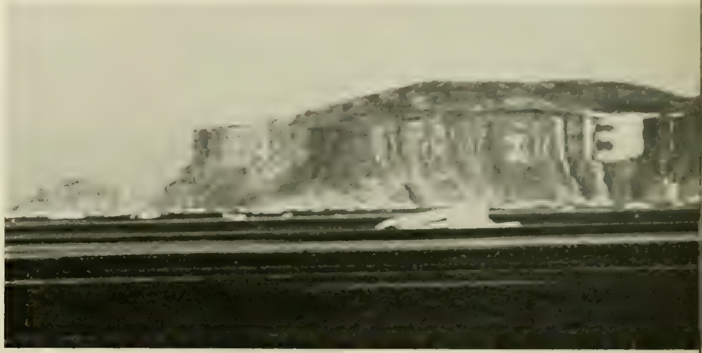
Near the mouth of Hamilton Inlet, a giant fiord that penetrates 120 miles into the interior of Labrador and discharges warmer water into the cold sea, there are several small islands that almost always "loom." This mirage is such a regular occurrence that ship captains who sail the coast habitually can set their course by it while still too far away to see the islands themselves.

In 1899, R. W. Wood, a British scientist, succeeded in reproducing mirages experimentally by viewing objects over a series of heated slate slabs. Since then, the optical conditions that produce mirages have been analyzed mathematically, and lenses can be made that will reproduce the effects seen in nature. These lenses are made of material of varying density, like the air, and form the same sort of "sandwich"—a dense layer between two layers of lesser density—that produces mirages in the atmosphere.

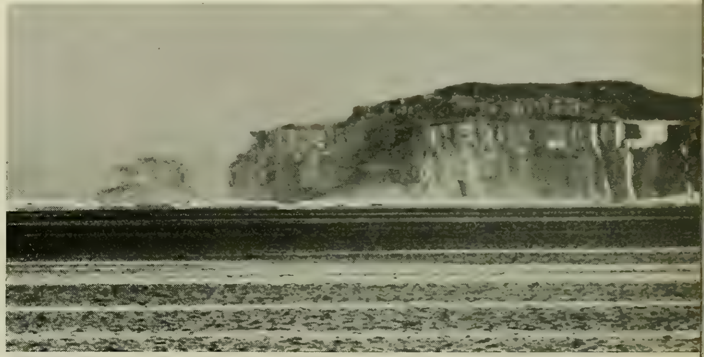
Most mirages are merely curiosities, but we do know that on at least one occasion a mirage altered the course of history. In 1818, Sir John Ross was sent by the British Admiralty to look for the Northwest Passage. He turned back in Lancaster Sound (situated in the Canadian Arctic between Baffin Island and Devon Island) because, according to his report, *Voyage of Discovery for the Purpose of Exploring Baffin's Bay*, he "distinctly saw land round the bottom of the bay forming a chain of mountains connected with those which extended along the north and south side." Ross then named these the "Croker Mountains" after a Secretary of the Admiralty. But his second-in-command, Lt. Edward Parry, who was to become a famous explorer in his own right, insisted that the mountains were no more than a fantastic optical illusion. Ross was the subject of ridicule and suspicion when he returned to London, despite his genuine contributions to geography. We now know that Parry was right, and Lancaster Sound *does* lead to the Northwest Passage. The Croker Mountains were a mirage.



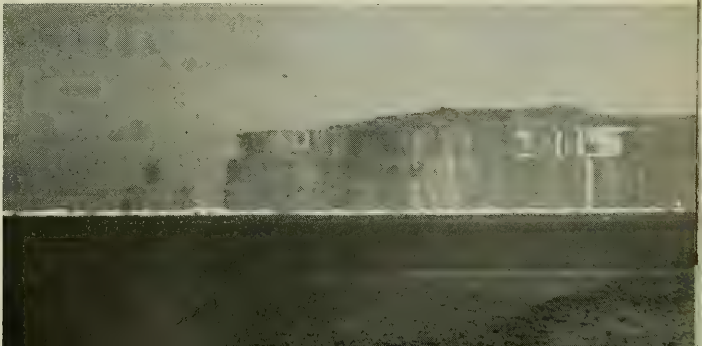
*Headland and small island on Labrador coast were photographed by author as his ship sailed past. Seen from nearby, above, shore appears only slightly distorted.*

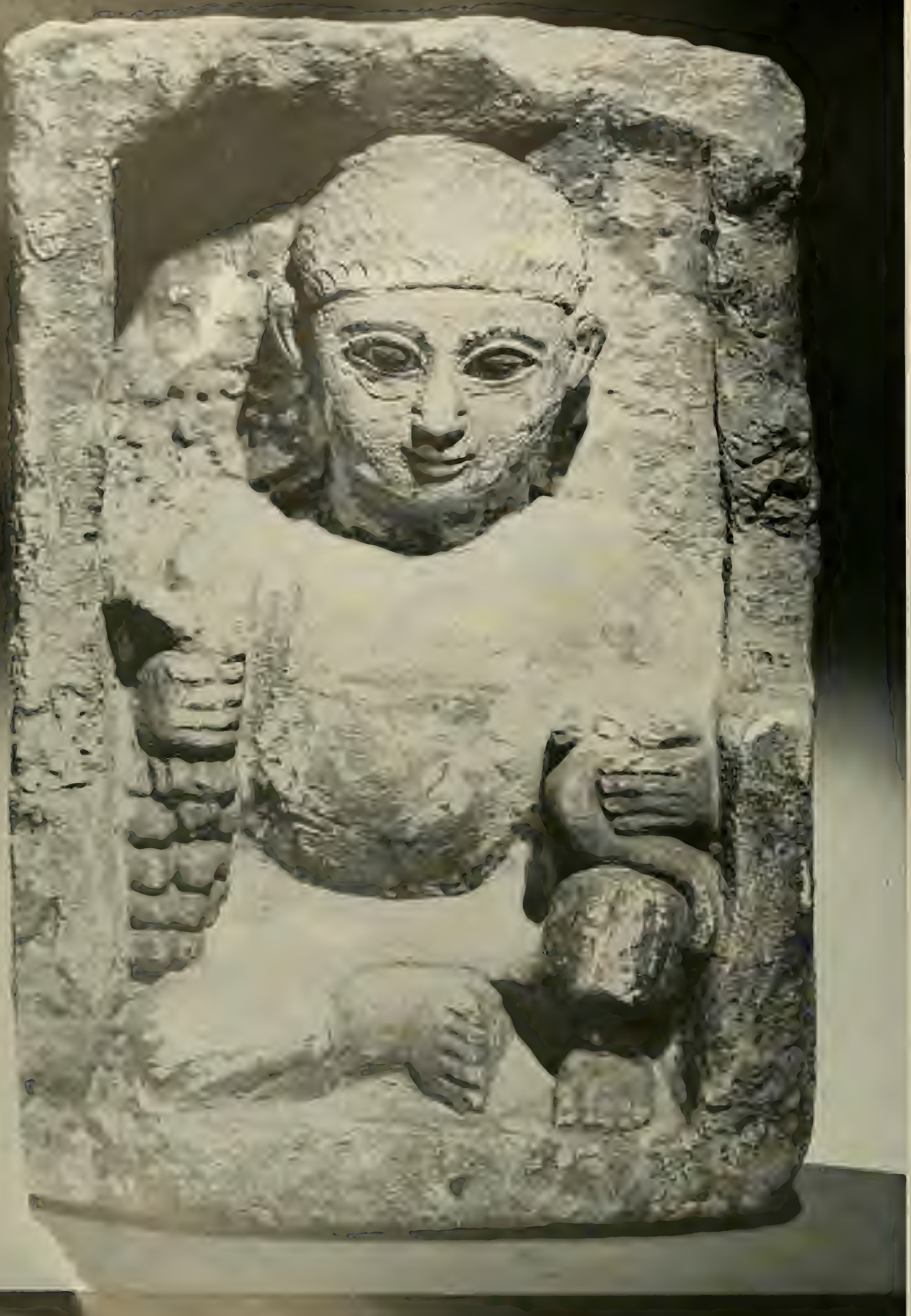


*Wavy line near the top of the headland marks the upper limits of an atmospheric "temperature inversion," which is causing the land to seem vertically stretched.*



*Left slope of headland begins to look like a cliff, above, and island on left changes its shape. Air stratification is most pronounced in photograph below.*





# The Cross and Orb in Egypt

### by JOHN D. COONEY

*Dioscoros and his sister, with Anubis, are shown on limestone stela in an attitude of prayer.*

It was about the year A. D. 50, according to an ancient tradition, when the Apostle Mark arrived in Alexandria carrying the Gospel to the Egyptians. The magnificence and intellectual feats of that fabled city then were commencing to fade under the rising glory of Rome, but only commencing. The Alexandrian Library probably still stood, and not far away was the magnificent Temple of Serapis with its "Daughter Library," the haunt of world-famed scholars. Tourists—and Egypt was even then a tourist country—gaped at the tomb of Alexander the Great with its golden sarcophagus, which contained the hero's body embalmed in honey. Dominating the city, sea, and countryside, the famed Pharos, or lighthouse, a scientific and architectural masterpiece, still flashed its warning light to mariners. The palace of the Ptolemies, looted of some of its treasures by the conquering Augustus, but still filled with royal collections accumulated over many centuries, looked down over these wondrous sights set in the midst of an opulent city.

Probably such masterpieces of Greco-Egyptian civilization meant little to Mark. His purpose was to bring the Gospel to the Egyptians, and in that he seems to have succeeded. What he could never have known, for it became apparent only long after his death, was that he was establishing the last great cultural period of ancient Egypt, the Christian culture of the Egyptians known as the Coptic period.

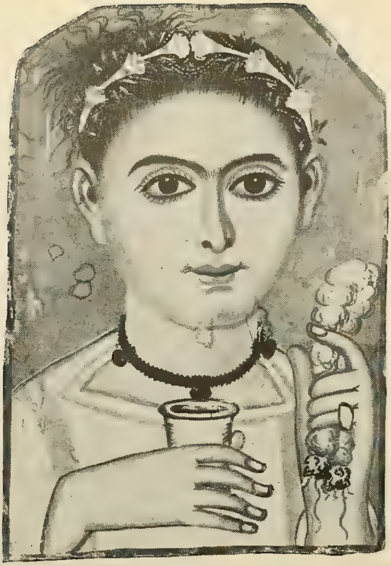
Here there is a difficulty, perhaps even a looseness, in the use of words. The adjective "Coptic" correctly is reserved for anything connected with Christianity in Egypt. This degree of precision is almost unobtainable; for instance, certain reliefs from Terenuthis are of uncertain religious affiliation but are of very marked style—one that we recognize as Coptic. So the word Coptic is used, somewhat ambiguously, to identify one branch of Christianity and a school of art, which may or may not be Christian.

Almost nothing is known of the progress of Christianity in Egypt during the first three centuries of its existence beyond the fact that it did spread through the country. By A.D. 350, Christians probably outnumbered pagans. Not more than a generation or two before that date, the cultural change introduced by Mark had made its first great contribution in a new form of writing the ancient Egyptian language. Writing had appeared under unknown circumstances in ancient Egypt about 3100 B.C., and during the following millenniums underwent changes in structure, form, and script. At all times, though, there must have been a great gap, as there was in Latin, between the written and spoken word, and reading and writing the various forms of Egyptian were confined to a limited percentage of the population. Over the centuries the form of the written language was changed from the pictorial hieroglyphic to the simpler hieratic and then to demotic, which, in Mark's time, was in general use. But even demotic was difficult to master.

*Painted stone stela, probably A.D. 300, from Antinoë is pagan in subject but Coptic in style.*

By the time Christianity came to Egypt, the educated classes had become bilingual, for Greek was the court and literary language under the Ptolemaic kings. This explains why so much Greek literature has survived until now in Egyptian papyri. In Lower Egypt, Greek probably predominated, but the average Upper Egyptian farmer must have known nothing of that rich tongue. The language of his Pharaonic ancestors was fine for speech, but written Egyptian, like Hebrew and Arabic, used no vowels. As a result, for one who lacked fluency in the language, an almost insurmountable difficulty was presented in writing it.

It was certainly in some ecclesiastical institution in Egypt that, late in the third century, a group of monks brilliantly solved the language difficulties of the time by establishing the system of using the Greek alphabet to write Egyptian (or Coptic, whose etymological derivation is obscure), and introducing for the first time since 3100 B.C. the written expression of vowels in Egyptian. To cover those few Egyptian sounds not known in the



*Faiyum, or funerary portrait, in tempera on a wood panel, was inserted over face of a mummy.*

Greek tongue some signs were continued from demotic. The clarity and simplicity of the Greek alphabet enormously simplified the task of reading and writing Coptic and, obviously, helped greatly in bridging the communication gap between Greek-speaking and Egyptian-speaking persons. But its chief value, anciently at least, was to develop a sense of individuality and importance among the less powerful classes in Egypt by making them literate.

Coptic does not rank high as a literary language. It produced only one great stylist, the famed Shenuda of the fifth century—a great orator, a brilliant writer, a theologian, administrator, monastery builder, and foe of paganism. For the most part, however, Coptic was devoted to religious writings, a translation of the Bible, and innumerable, rather childish stories of now almost-forgotten saints. In the last two centuries Coptic has been of enormous interest, as it was one of the keystones in the rediscovery of reading hieroglyphic. Above all, it is our sole, if precarious, guide to the pronunciation of the language of Pharaonic Egypt.

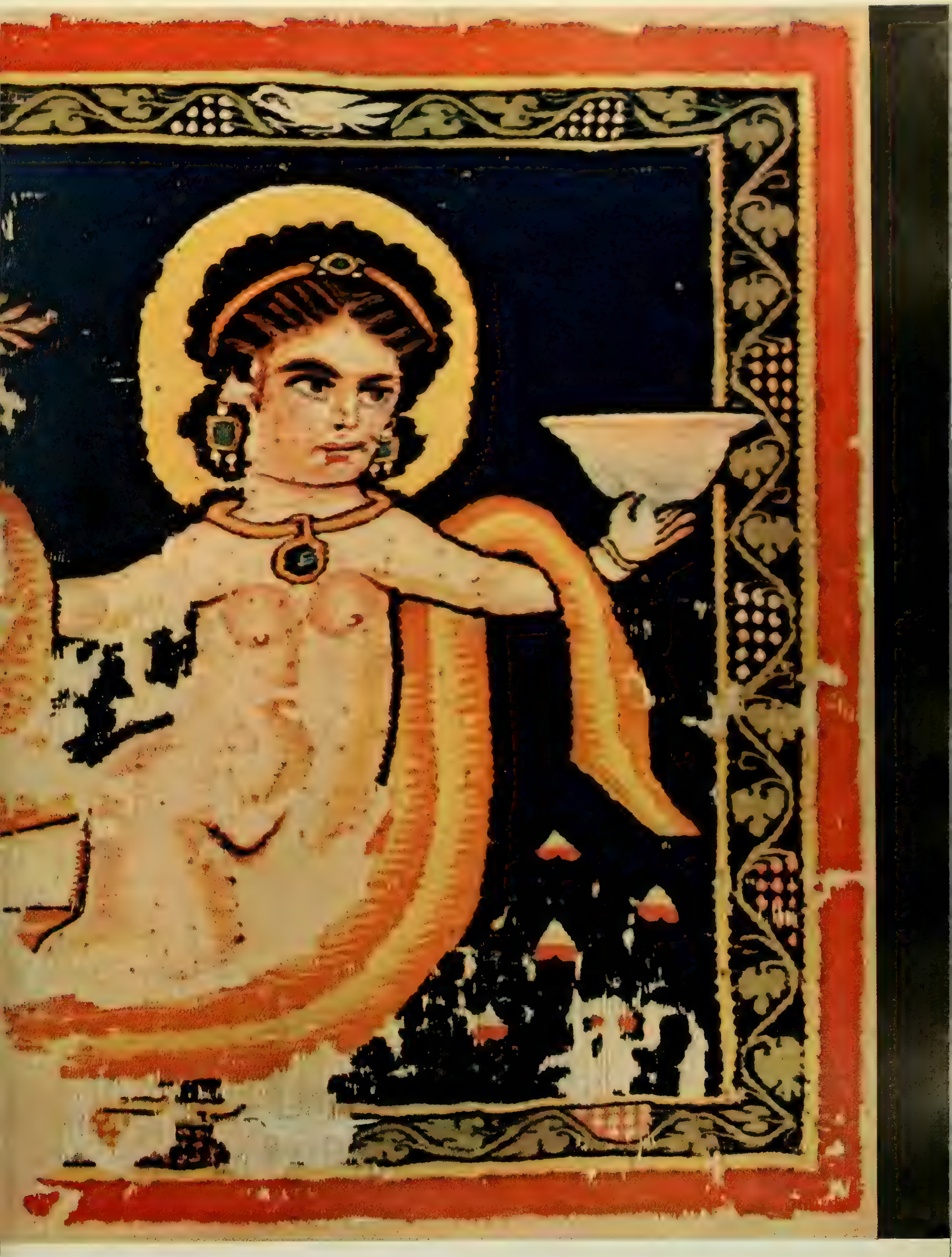
This clear development of the Coptic language and its impact on morale in Egypt is not paralleled in the development of Coptic art. Among the many reasons are that Egyptologists disdain the Coptic period as too late for their attention; inscribed, dated, or documented works of art are few; and, chiefly, far too few Coptic sites have been scientifically excavated or studied. While much existed, little has survived; early Coptic structures were frequently built directly over pagan monuments—even within them—and the Egyptological zeal of nineteenth-century excavators swept away Coptic remains as barriers to the sought for dynastic remains. Losses must also have been considerable at the time of the Arab conquest in the seventh century, and the destruction in later persecutions is known to have been very great. It is surprising, on reviewing modern studies in Coptic art, to find that the first important study of surviving Coptic architecture in Cairo was not produced until the publications of A. J. Butler in the 1880's. A charming and still-important work, it gives an unflattering picture of the intellectual level of the Copts at that date, when not even they were remotely interested in their own culture. Also in the nineteenth century Lord Curzon (on his productive tour of the monasteries of the Levant) had reported conditions much the same.

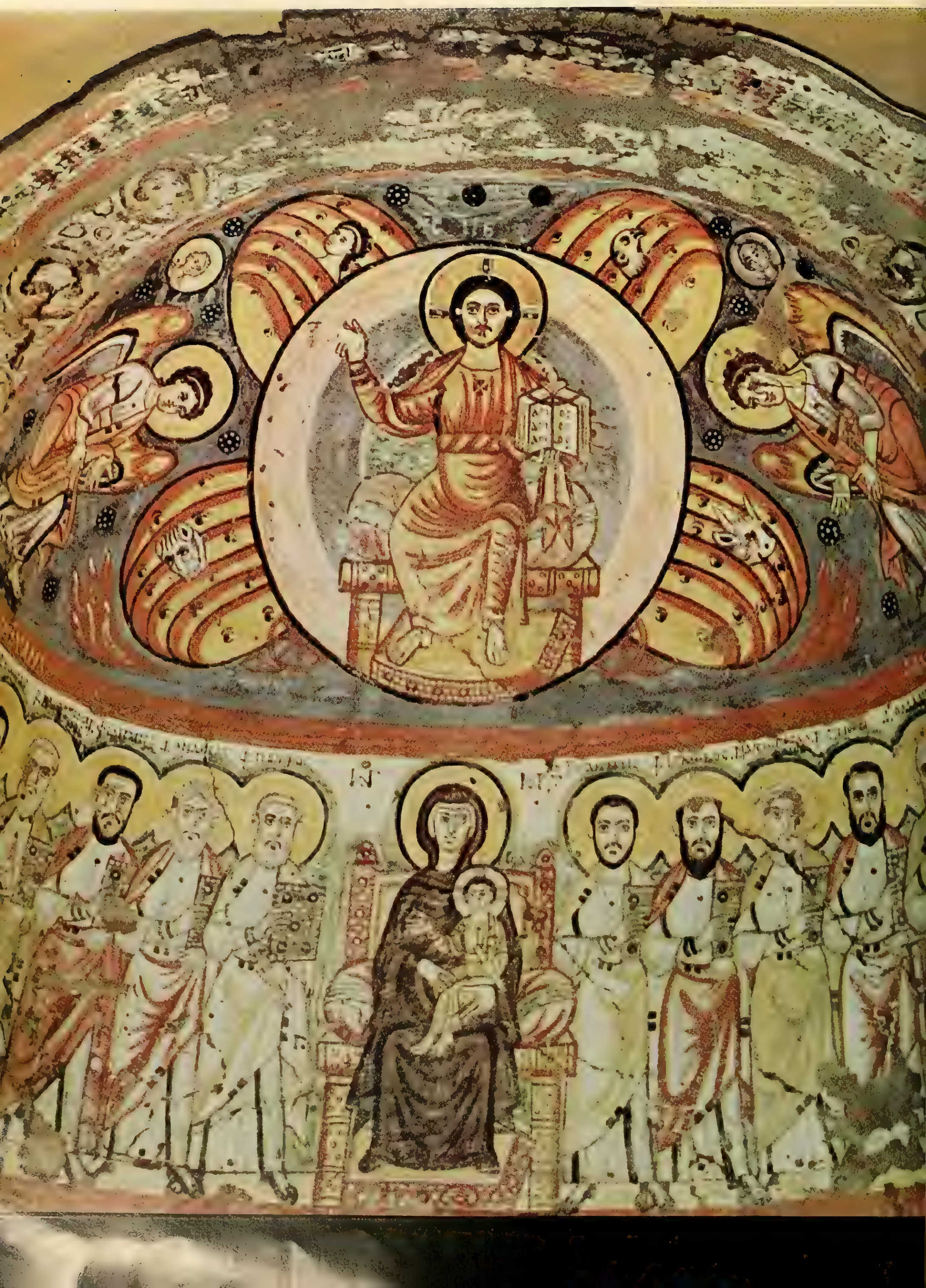
Coptic art was slow in maturing. For centuries after adopting Christianity, the Egyptian Christians incorporated their pagan inheritance in their religion. For whatever reason, as late as the fifth century monks and laymen of undoubted orthodoxy bore names like Horus, Apollo, Amon, or Anubis, all names of contemned pagan deities. So it was with the art. The form, if not always the meaning, of typical Hellenistic or Roman monuments and objects seems to have served the Copts adequately. It is hard to find anything in the way of purely Christian art in Egypt before the fourth century, and there is little of that date that is unquestionably Christian.

When Christian art did appear it was not a separate stylistic movement inspired by Christian artists seeking a new kind of expression, but in form, at least, it followed the style then current in the country, with the addition of Christian subject matter. Evidence is still lacking for conclusive proof of this statement, but a strong argument could be developed from the change in style of the Faiyum, or mummy portraits (funerary portraits in wax and tempera on wooden panels), which certainly end in full Coptic style, whatever the religion of the subject, and a similar trend is evident in mummy cartonnages.

The uncertainty surrounding the beginnings of Coptic art is illustrated in the stela shown on page 41, an example that is known to be typical of a cemetery at Terenuthis in the Nile Delta dating about A.D. 300. Here Dioscoros—described as "fond of his brothers" —and his sister Heraklea, who seems to have died at the age of thirteen, stand in the attitude of prayer (*orans*) in the presence of Anubis, the sacred jackal. Within the past months it has been argued, very reasonably, that these gravestones are actually Christian, their pagan symbols being due to the unquestioning acceptance of a time-honored heritage, the original meanings of which had long since been forgotten. It hardly matters if the claim that these bear the earliest Christian inscriptions yet known will be generally accepted, for, pagan or Christian, they are so far the earliest monuments to show the mature Coptic style.

*Nereid within the border of birds and flowers appears in wool and linen tapestry, ca. A.D. 300.*





At just about the same time (A.D. 300), far to the south of Terenuthis, what may have been a studio was producing sculptures in the Coptic style. That was at Sheikh Ibada near Antinoë, where there apparently was an important shrine of the goddess Isis. The sculpture is typical of the work of this Upper Egyptian school (*page 40*). All the monuments represent boys, standing or seated within a niche, in most cases clasping a dove and a bunch of grapes, symbols of the goddess Isis in whose service these novices were dedicated. In subject the monuments are pagan, but in the large eyes, squat bodies, and disregard of factual proportion, there are basic elements of Coptic style.

Perhaps contemporary with these Isis sculptures—but in any case not much later in time and apparently from the same site—are a series of Coptic sculptures that seem to come from the same workshop as the pagan monuments. Christian signs, chiefly the cross and orb, were substituted for the symbols of Isis. Apart from their details, these monuments are indistinguishable from pagan prototypes. Unfortunately, the excavations at Sheikh Ibada were clandestine, and so we know nothing about them. Nor is it yet possible to trace the influence of the school on later work.

By the fifth century Coptic art was well developed. It is only a slight exaggeration to say that the fifth and sixth centuries marked the great period—development and decline, almost the disappearance—of Coptic art. If Coptic art is never truly free of an element of provincialism, even in its greatest period, it is hardly to be wondered at. The wonder is that in those difficult times anything of consequence was made. Egypt was a poor country exploited as a crown province both by Rome and Constantinople. The Coptic clergy, devout and sincere, were intolerant and opinionated. Their attacks on pagans and pagan institutions in Alexandria were brutal and shocking, and the conduct of the patriarch was all too often vigorous rather than charitable. The Church was generally addicted to theological disputes, and because it refused to give up its belief in the single nature of Christ (Monophysitism), it was declared heretical by the Council of Chalcedon in A.D. 451. So it was that in the middle of the fifth century the Copts became isolated from both Eastern and Western Christianity.

In this unfavorable climate, architecture and sculpture flourished. The Church had considerable political power and did receive gifts of buildings and perhaps even funds from the court at Constantinople. Curiously, even in the fifth century, Christian subjects were still rare in Coptic sculpture—and Coptic sculpture is largely relief. One would expect the various episodes of the life and death of Christ to be represented as the basis of the new faith, but such scenes are almost unknown. The Coptic—probably clerical—mind seems to have been nationalistic and somewhat petty in choosing religious scenes for the sculptures. In place of scenes of the life of Christ, which were the mainstay of the Western Church, the Copts depicted conversions and martyrdoms of Eastern saints, and only a few of them are readily recognizable today. All too often, perhaps even in the majority of scenes, the meaning is so obscure that precise identification is often impossible and almost always debatable. The enigmatic scene in a relief now at the Princeton Museum (*page 46*), has been imaginatively identified as the Church receiving a military saint into heaven. Such groups must have had more meaning to the Coptic mind than they have to us. The doll-like figures are typical and, rather touchingly, like amateur actors they stare at the spectator. The Christian scenes found on ivory objects of Alexandrian origin are, on the other hand, easy to identify for they are usually of biblical subjects.

*Fresco painting from the Monastery of St. Apollo shows Christ, angels, apostles, Virgin and Child.*

Coptic sculpture shows diversity to the extent that it lacks unity. This could be considered either as a merit or a defect, but it does leave the impression that a series of local schools were working in Egypt at the same time and in very different styles. The Princeton relief cannot be far in time from the reliefs that can now be seen in The Brooklyn Museum. Yet all three are different. The frieze of animals galloping within foliage is a splendid example of Coptic ability to produce architectural ornament in limestone in the Hellenistic spirit. It is difficult to reconcile this with the style of the Princeton relief or the one below, which is attributed to the school of Ahnas in Upper Egypt, perhaps the best source for fine Coptic sculpture. Here the subject seems to be the god that personifies the Nile, and the earth goddess Gaea, or Ge, amid lotus flowers. The angular, stylized treatment of the bodies with deep undercutting is as typical of this school of Ahnas as is the use of pagan subjects. The sculptors at this site did produce fine reliefs with Christian themes, but usually they show boys, called *putti*, gracefully displaying a cross or some other Christian symbol, the treatment being entirely classical pagan. The pagan tradition, culturally at least, was still strong, and even at this late date—the fifth century, and into the sixth—some remarkable examples of Hellenistic style are known to have survived.

*Lotus flowers form background for god of the Nile and nymph. Relief is from school of Ahnas.*

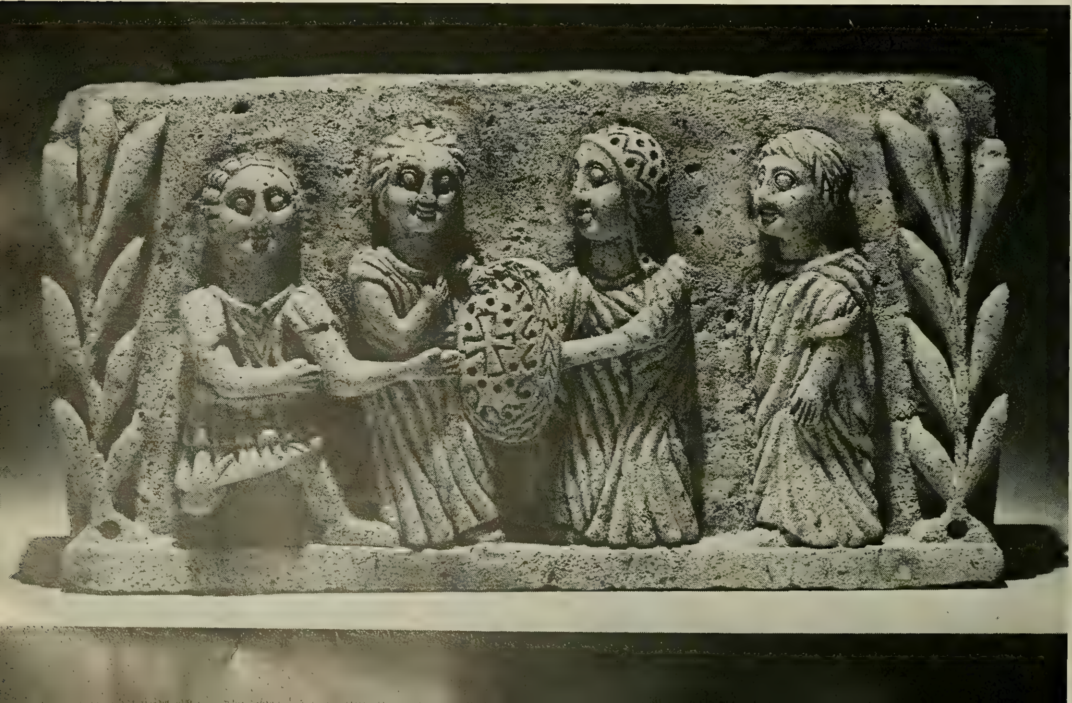
In the sixth century, for whatever cause, a new and rather widespread trend toward a flat relief seems to have overtaken Coptic art. The work gives the impression of having been created by a series of incisions and is suggestive of the technique of woodcutting. Even when the subjects are interesting, as is often the case, the workmanship is dull; the reliefs leave one with the impression of inferior work produced by artisans cut off from the cosmopolitan world. It was the beginning of the end of the brief life of Coptic art.

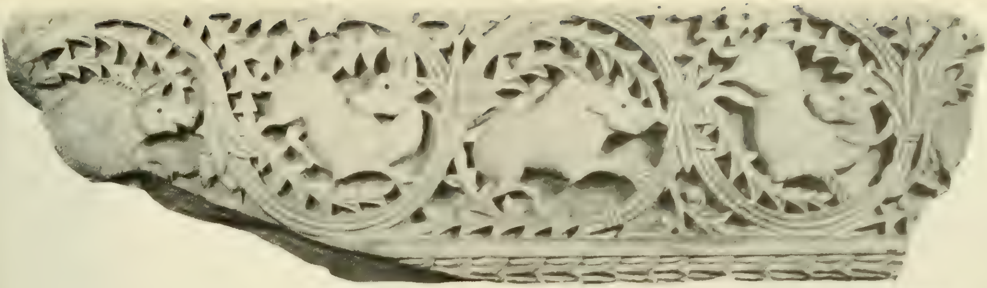
With almost no exceptions, these sculptures were produced for churches and ecclesiastical buildings. Tombstones, rarely of more than historical interest, are perhaps the only exceptions to this statement. There seems to have been no use of sculpture for public buildings or for private use, and there is almost no mention in Coptic literature of works of art. Occasionally, a writer mentions the destruction of pagan monuments or the donation of ritual vessels to a church, but otherwise there is silence.

Judging from the remaining ruins, early churches of the Copts seem to have been impressive monuments. Several of these were famous throughout the early Christian world. One in the desert not far from Alexandria was devoted to St. Menas, who was always shown flanked by kneeling camels. Pilgrims came from all over Europe to visit this great shrine, and the little flasks in which they carried back miraculous water from the holy spring have survived by the thousands. The building, in large part the gift of a Byzantine emperor (Arcadius) late in the fourth century, was an impressive structure in marble and limestone in the form of a basilica of cruciferous plan. The materials, form, and floor plan of this shrine are typical of other buildings constructed from Sakkara into Upper Egypt during the next century. In this great period of Coptic art the churches and similar important buildings were almost always built of fine limestone. Construction in brick or mud with the use of many small domes, characteristics which today are associated with Coptic churches, came into use at a later date when the Church was impoverished. This explains the present appearance of the churches in the older section of Cairo, many of which were founded at a very early date but were so completely renovated during the Middle Ages that they retain few early details.

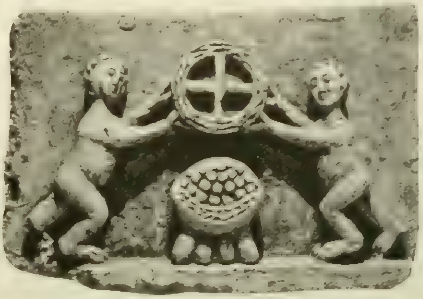
The early churches were divided into nave and aisles by the use of columns frequently torn from earlier pagan buildings; they were often made of costly hard stone such as marble, porphyry, and black and red granite. They were topped by limestone capitals of the most intricate workmanship, one of the important original developments of Coptic architects. Some were imaginative variations of the traditional Corinthian capitals; others combined Christian devices with elaborate vine patterns; and, finest of all, there were the so-called basket capitals, which were versions of woven work in stone. Most of the architectural details were painted to the point of gaudiness. Long, narrow panels of wood were frequently used as friezes above the capitals. Their coarse carving was disguised with

*Stone relief from Upper Egypt is interpreted as reception of a military martyr into heaven.*





*Exceptionally fine relief of various animals within foliate frames is of the Ahnas school.*



*Two putti support Coptic cross over table in what is possibly scene from the New Testament.*

a heavy layer of gesso to which paint was applied, and, unlike most of the rest of Coptic art, they continue some of the traditional scenes of river life so frequent in the Pharaonic period.

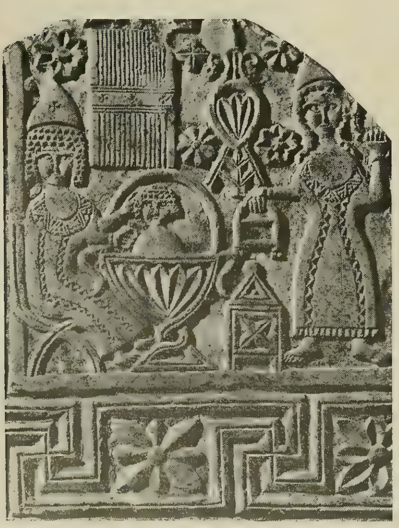
Not all ecclesiastical architecture, even in the early period, was on this splendid scale. In Upper Egypt, far from the great centers, and particularly in Nubia, this relative luxury was out of reach. In remote areas the Copts took over the deserted pagan temples, sometimes building a modest brick church in the vast outer courts, and many, covered with rubbish, have survived into recent times. But more frequently the builders took one of the smaller, inner rooms, often the ancient sanctuary, covered the walls with plaster and carved a niche in the back wall. These simple renovations seem to have provided satisfactory, if not impressive, places of worship. In many cases the plaster applied to hide the pagan reliefs from the faithful has preserved them for our age.

In both the simple provincial churches and the stately stone structures of Lower Egypt the walls were literally covered with great frescoes. Even in later and poorer times the tradition was continued, and an echo can probably be found in the icons that cover the altar screens in every Coptic church today. These early paintings are great, complex compositions of Christ in glory, the Ascension, the Virgin enthroned, and other basic Christian themes. These are the very scenes not found in relief sculpture, and their absence there can possibly be explained by their presence in painting. The colorful fresco shown on page 44 is from the great monastery of Bawit in Middle Egypt and was probably executed in the sixth century. It looks monumental, but it is actually of rather small dimensions. Similar paintings, drawn from the Old and New Testaments, were painted on the plastered walls of the converted pagan temples in Upper Egypt and especially in Nubia, where many have survived to this day. The tradition remained very strong there, for recent discoveries have shown that even as late as the twelfth century the Nubian churches were decorated with frescoes of biblical subjects. In style these paintings are clearly provincial versions, often spirited ones, of the Byzantine school centered in Constantinople. The influence may have been direct or it may have come through Syria. From two discoveries also made at Bawit we know that icons were already in use in the sixth century. From the little painting that has survived from this period one suspects that it had more spirit than did the sculpture.

The most famous product of Coptic artists was certainly their textiles, which have survived in quantity. Their preservation is due to a curious reversal of Egyptian burial customs. In ancient Egypt, apparently for ritual reasons, people were buried in plain linen cloth. It is well established that these Egyptians had patterned textiles, embroideries, and beadwork fabrics, which, while not used in burials, were sometimes deposited in the tomb. With the rise of Christianity in Egypt the church authorities railed against the ancient practice of mummification, presumably only because of its pagan connections. In any case the practice, a costly one at best, was gradually disappearing. Sometime around the third century we find burials of Egyptians, presumably Copts, in their elaborately patterned clothes. It is quite plausibly assumed that these were their everyday clothes, and that with the dropping of mummification the related custom of using plain linen was also dropped. This change in burial customs has preserved for us the greatest collection of textiles surviving from any ancient civilization.

The bulk of the textiles were tapestry woven; those in loop technique were less frequent. Embroideries were rare, as was the technique of resist dyeing. (The latter is a method in which the design is sketched on a fabric and areas that are not to have color are covered with a substance, such as wax, that will not absorb dye.) The materials used were wool and linen, as cotton was unknown until a much later date; the silks seem to have been imported. The sudden appearance of these splendid fabrics has led some to think all of them were imported, but because of the enormous numbers that have been found it seems probable, although we have no knowledge of how or where they were produced, that they were made in Egypt.

In design and subject matter these fabrics closely follow the development of Egyptian sculpture of the same period. The earliest surviving textiles are clearly Hellenistic in style and subject, although it must be stressed that the exact dating of Coptic textiles is far from settled. Excavations have been of little assistance in working out sequence or dating, mainly because of the lack of inscriptions. The splendid panel on page 43 with a reclining nereid is probably as early as the third century. Not only is the subject classical and spirited; the colors are brilliant and clear. This piece was probably a detail of a wall hanging or tapestry. Far larger, if slightly later, examples are of so great a size that they must have served as wall hangings or curtains, a use unknown in ancient Egypt. Many of these materials have come down to us as discarded fabrics that were used to support the head of a corpse or to fill out spaces at the sides of coffins. Rugs, which also probably first appeared somewhat to the east, now became known for the first time in Egypt, although woven mats had been used as rugs at an earlier date. Almost every Roman period dump heap in Egypt has yielded discarded textiles of Coptic origin. Many of the subjects were standard and appear to have been used over a long period of time. Judging from the examples we have, scenes of classical origin and style continued in use well into the fifth century.



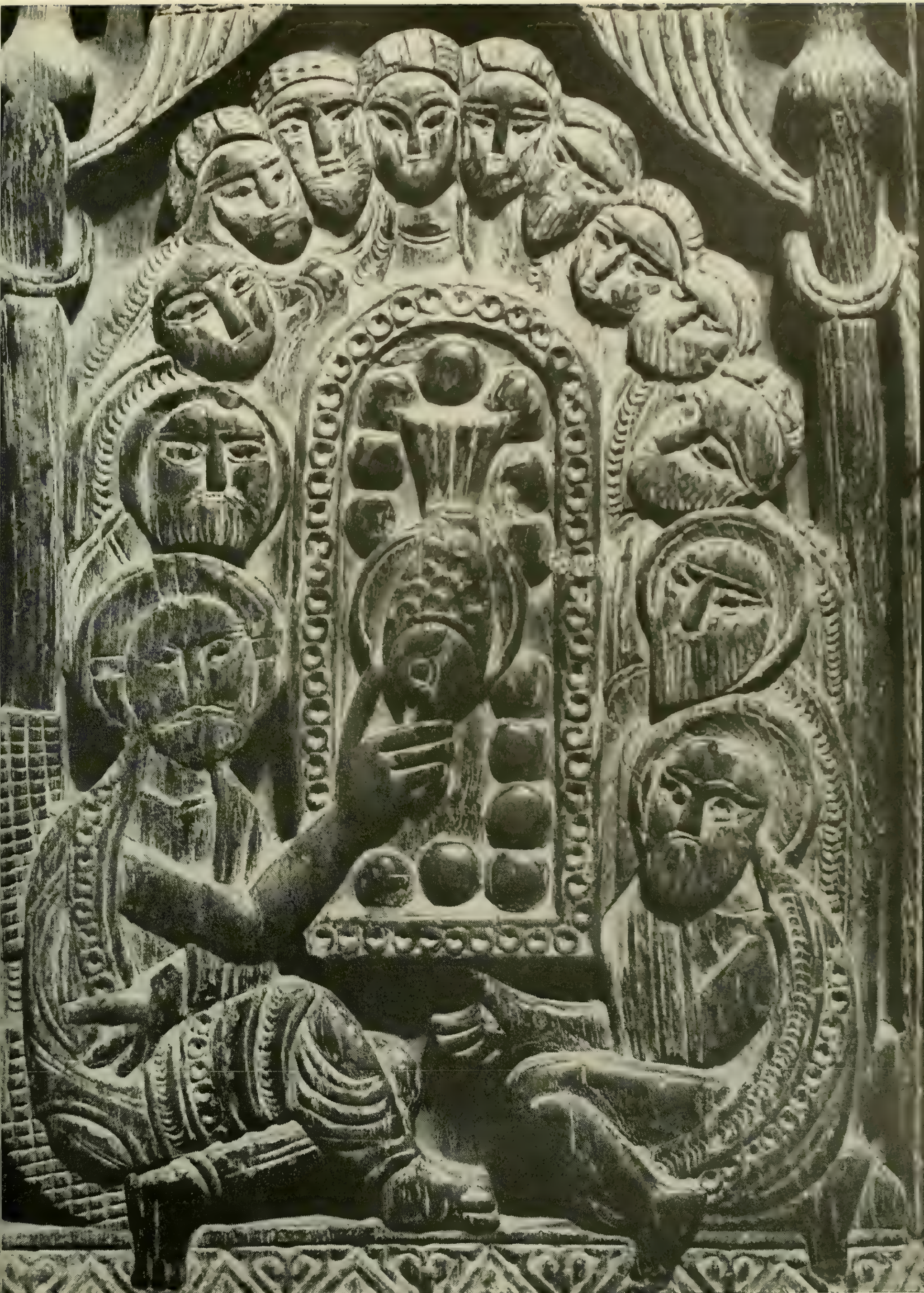
*Bathing of the baby Jesus, a subject rare in Coptic art, is seen in this sixth-century relief.*

*Wooden altar screen in Church of Abu Sarga, in Old Cairo, shows scene of the loaves and fishes.*

One of the mainstays of the textile industry was the manufacture of elaborately patterned clothing for daily use. The most usual type was a tunic of very ample proportions—the Copts seem to have wanted to bulk large—looped up around the waist with a cord. The patterned areas were restricted to long strips that went around the neck and ran down the front of the tunic, cuffs, and sometimes the roundels, or inserts, on the chest area. The backgrounds on which these woven parts were stitched were of one color. The earlier tunics were of light yellow or cream-colored wool (now turned brown), but the later tunics were of flamboyant exuberance. They flaunted every shade of red, orange, green—light and dark—purple, and brown, and when the even more vividly patterned strips were added, the effect of several persons gathered together must have been arresting in the extreme.

Christian subjects appear at a rather late date in these textiles and they remain rare. With the advent of the sixth and seventh centuries, the classical designs give way to the more abstract—usually conventionalized foliate designs or interlacing geometric patterns. This is in keeping with the development found in relief sculpture. The influence of these later Coptic textiles on Islamic fabrics made in Egypt in the later seventh and eighth centuries is obvious and extensive.

WITH the Arab conquest of Egypt in 641 the progress of Coptic art was halted and its ultimate disappearance made certain. Few details are available of conditions in Egypt immediately following the conquest, but two facts at least are clear. Many of the Copts were converted to the religion of the conquerors, and with the establishment of Islam as the state religion, the Coptic Church lost political and economic power. Again we are faced with the lack of dated monuments, tombstones excepted, and while some work was executed after the conquest it seems to have been only an afterglow of earlier work. Coptic craftsmen were employed by the conquerers, but the Copts soon were in the uncomfortable position of being a persecuted minority. Persecution was sporadic, but it must have weaned away the weaker of the faithful and discouraged Coptic invention in the arts. Within a century or two following the conquest, Coptic work had merged with Islamic to the extent that they were indistinguishable, except for the occasional use of Christian themes by the former group. A few, scattered woodcarvings, such as that at right, were executed early in the Middle Ages and were charming examples of folk art. They were also the last expression of Coptic art, and even they are almost submerged in the spirit of Islam. The Coptic language lingered as the liturgical tongue of the church, but was understood by fewer and fewer. It is said to have died out as a spoken language in the seventeenth century. But it is thought unlikely that it lingered even to that late date.



# SKY REPORTER

## Study of Mars is accelerating

By Thomas D. Nicholson

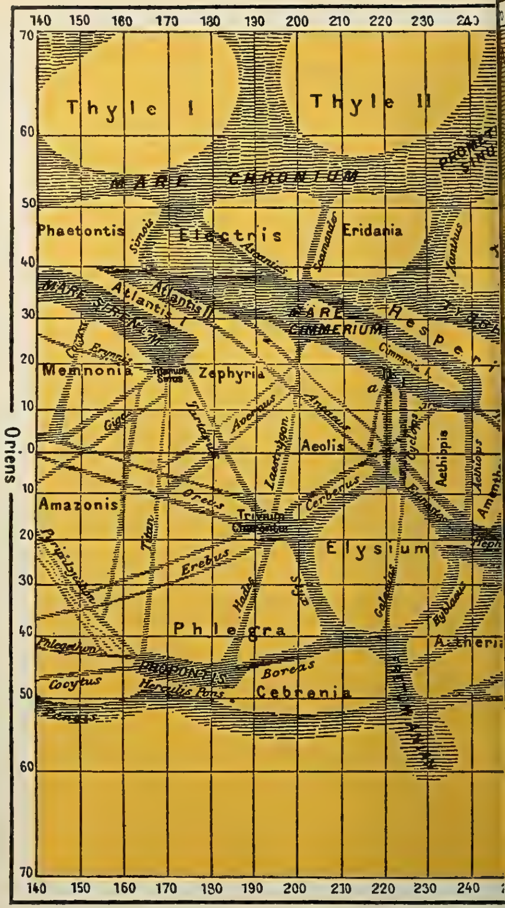
One of the memorable periods in the annals of investigations of Mars was the fifteen-year interval between 1877 and 1892. The interval began and ended with two of the most favorable oppositions of Mars during the centuries in which it has been observed by telescope. On September 5, 1877, Mars came within 35,050,000 miles of earth. Fifteen years later, on August 4, 1892, the distance between the planets was less than 35,100,000 miles. During the six oppositions that occurred between these years, the distance from earth to Mars was much greater than at either end of the interval. But a famous discovery made at the time of the 1877 opposition heightened interest in the planet considerably, so that astronomers waited anxiously for each successive opposition to occur, climaxed by the excellent position of the planet in 1892.

The director of the Observatory of Milan, Giovanni Schiaparelli, planned an extensive program of observations for the summer and fall of 1877 to take advantage of the close opposition of September 5. The apparent size of Mars in the skies above the earth at that time was larger than it would be again for fifteen years. Indeed, for several months before and after that date, Mars would be larger in apparent size than it could be expected to be at some later oppositions (*see illustration, page 52*).

During his observations, Schiaparelli carefully sketched the surface details he could see through his telescope. Upon reviewing his sketches, he found that many of them contained dark, relatively straight lines, consistently in the same positions. When he later prepared drawings of the appearance of the Martian surface, refreshing his memory from the sketches, he included these dark markings.

Earlier observers of Mars had not noticed such markings, although sketches of the planet's telescopic appearance dated from the time of Christian Huygens, in the mid-seventeenth century. Many early observers had noted, and represented in their drawings, the prominent dark areas that had been given the names of bays, seas, gulfs, and oceans, and the lighter-colored "continental areas." The labels given to these features did not really reflect the belief that these were bodies of land and water on Mars, but rather followed the convention that had been used in naming features on the moon's surface.

Thus, Schiaparelli gave the name *canali* to the new dark markings he had found. His use of the word was in reference to their channel-like appearance, and the Italian word *canali* can be translated as "channels." Unfortunately, *canali* also bears a close resemblance to the English word "canal," and as such it was translated by popularizers of science. To many persons, canal is suggestive of waterways planned and constructed by intelligent beings, and a vast body of literature arose concerning the possibility that the canals were evidence of intelligent life.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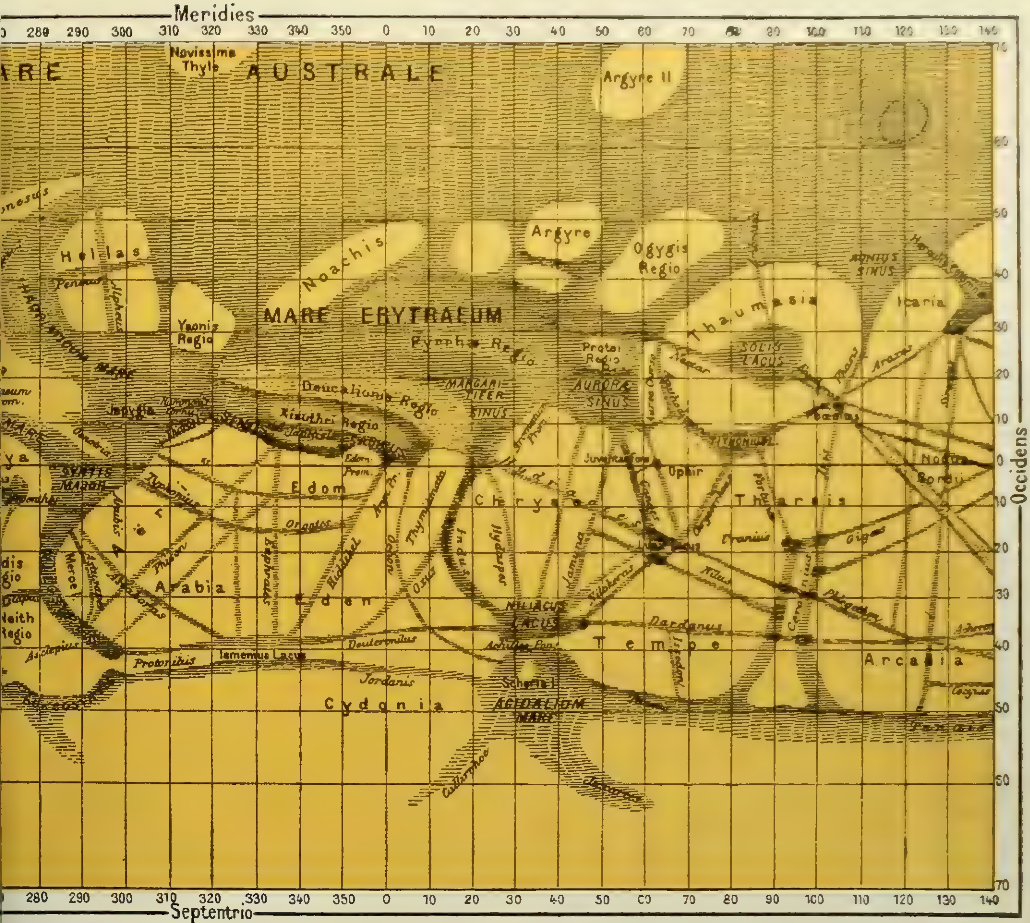
Oriens
Thyle I
Thyle II
MARE CHRONIUM
Phaetontis
Electris
Eridania
Simois
Scamander
Axius
Atlantis
MARE SIRENUM
MARE CIMMERIUM
Hesperia
Memnonia
Zephyria
Titanum Sinus
Aeolis
Gigas
Sirenius
Avernus
Laestrygon
Cyclops
Aethiopis
Amazonis
Orcus
Cerberus
Trivium Charontis
Elysium
Titan
Erebus
Hades
Styx
Galaxias
Phlegra
Phlegethon
PROPONTIS
Boreas
Cocytus
Herculis Pons
Cebrenia
Eunostos

In the years following the discovery of the Martian canals, many other observers looked for them and found them. Still others could never see anything in the telescopic appearance of Mars bearing any resemblance to them. Schiaparelli, however, saw the markings repeatedly. With each succeeding opposition, and the opportunity each gave him to study the planet, he continually improved his drawings and maps of Mars to show the presence of the canals, among the other permanent markings he observed. His map, reproduced above, is still one of the best drawings of the planet's appearance. Based on observations he made from 1877 to 1886, the map locates and names the principal canals that he identified with certainty. It also represents a number of the canals as being double, and shows the larger dark areas, or oases, as they came to be called, where several canals intersected.

Another extremely valuable chapter in the history of Martian research may be written when the spaceship Mariner IV swings by Mars about the middle of July this year. In the past, scientific interest in Mars has generally in-


Meridies
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Novissima Thyle
AUSTRALE
Argyre II
Hellas
Noachis
Argyre
Ogygis Regio
Yaonis Regio
MARE ERYTHRAEUM
Pyrrhae Regio
Protei Regio
Thaumasia
Icaria
SOLIS LACUS
AURORAE SINUS
MARGARITIFER SINUS
Deucalionis Regio
Xisuthri Regio
Edom
SYRTIS MAJOR
Chryse
Ophir
Juventae Fons
Tharsis
Arabia
Eden
Indus
Hydaspes
Ganges
Nilus
Uranius
Gigas
NILIACUS LACUS
Achillis Pons
Dardanus
Tempe
Arcadia
Deuteronilus
Protonilus
Tamenus Lacus
Jordanis
Scheria I
Cydonia
ACIDALIUM MARE
Callirrhoe
Occidens
Septentrio
10
20
30
40
50
60
70

Map of Mars follows the convention of labeling dark areas as if they were bodies of water. Based on observations of Schiaparelli, map also includes the controversial "canals."

creased every 15 or 17 years—the interval at which Mars makes its closest approach to the earth. The last significant year in that cycle was 1956, and the next will be in 1971. This year, 1965, is clearly out of step as a usual year of interest in Mars. Previously, astronomers could observe only the region of the universe visible from earth, but the space age has given them the opportunity to select more freely the time and place of their observations.

In past decades, telescopic observations of Mars in the years of favorable oppositions have produced a good deal of our knowledge about the planet's physical features. These observations have also produced some controversy, especially over the well-known canals. Mariner IV may clear up this controversy and uncover other valuable facts should it succeed in furnishing us with photographs when it passes by the planet in July.

Mars becomes a prominent object in earth skies at intervals of about two years and two months or, more precisely, 780 days. This interval is the synodic period of Mars—the time it takes the planet to return to a given position in our sky relative to the sun. For example, if Mars should be observed at opposition, exactly 180 degrees around our sky from the sun, on a given date, it will return to that same position (opposite the sun) after 780 days have elapsed. Throughout most of the duration of the synodic period, Mars is faint, and located so close to the sun that it is not easily visible from earth. To see why the planet seems to enter and leave the evening sky quickly, let us examine the circumstances that preceded and will follow the opposition that occured this past March 9.

On February 17, 1964, Mars was in conjunction with the sun, on the far side of its orbit in relation to the earth. Its distance from earth on that date was about 220,500,000 miles. It was not until the end of August, 1964, that Mars became separated from the sun by 45 degrees; it rose in the morning sky three hours before the sun. By then, it had approached to within about 194,300,000 miles of the earth and had a stellar magnitude of +1.7, hardly brilliant. In early December, however, Mars was 90 degrees

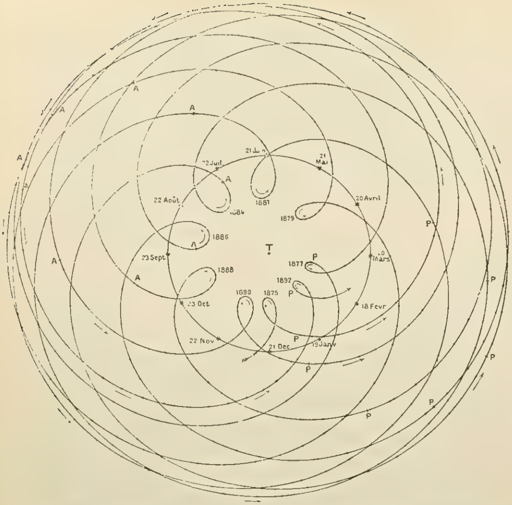
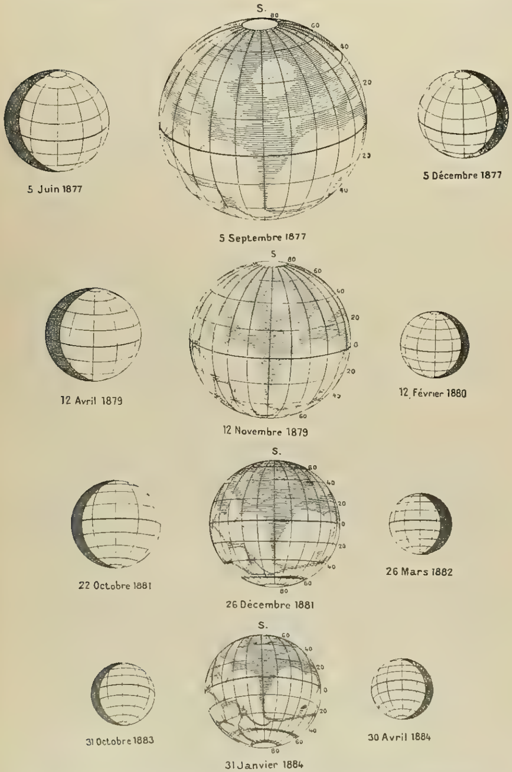


**CHART** shows distance between earth and Mars over eight synodic periods, from 1875 opposition to that of 1892. In 1877 and 1892, Mars was 35 million miles from earth.



**RELATIVE** size of Mars is compared over four oppositions. The comparison also shows how the planet's apparent size changes rapidly before and after the oppositional periods.

**DR. NICHOLSON**, the regular author of this column, is also Chairman of **THE AMERICAN MUSEUM-HAYDEN PLANETARIUM.**

west of the sun, rose about midnight, and remained visible until dawn. About 121,800,000 miles away, it had brightened to magnitude +1.0.

After early December, 1964, the planet brightened rapidly as its distance from the earth decreased. On January 9, 1965, it was high in the east at midnight, with magnitude +0.3, and was 94,190,000 miles distant. A month later, on February 9, it rose shortly after sunset, and had become easily noticeable among the stars of the early night, at magnitude −0.4. It was then 71,650,000 miles from earth. Then, on March 9, as we mentioned above, it rose at sunset, and was an outstanding object among the stars all night long. At its distance from earth of about 62,200,000 miles, it had a magnitude of −1.0. A month after the opposition, on April 9, it is 70,100,000 miles away and has a magnitude of −0.5. In another month, by May 9, the distance will increase to 87,800,000 miles and the brightness will fade to +0.1. By then, Mars will be setting in the west shortly after midnight.

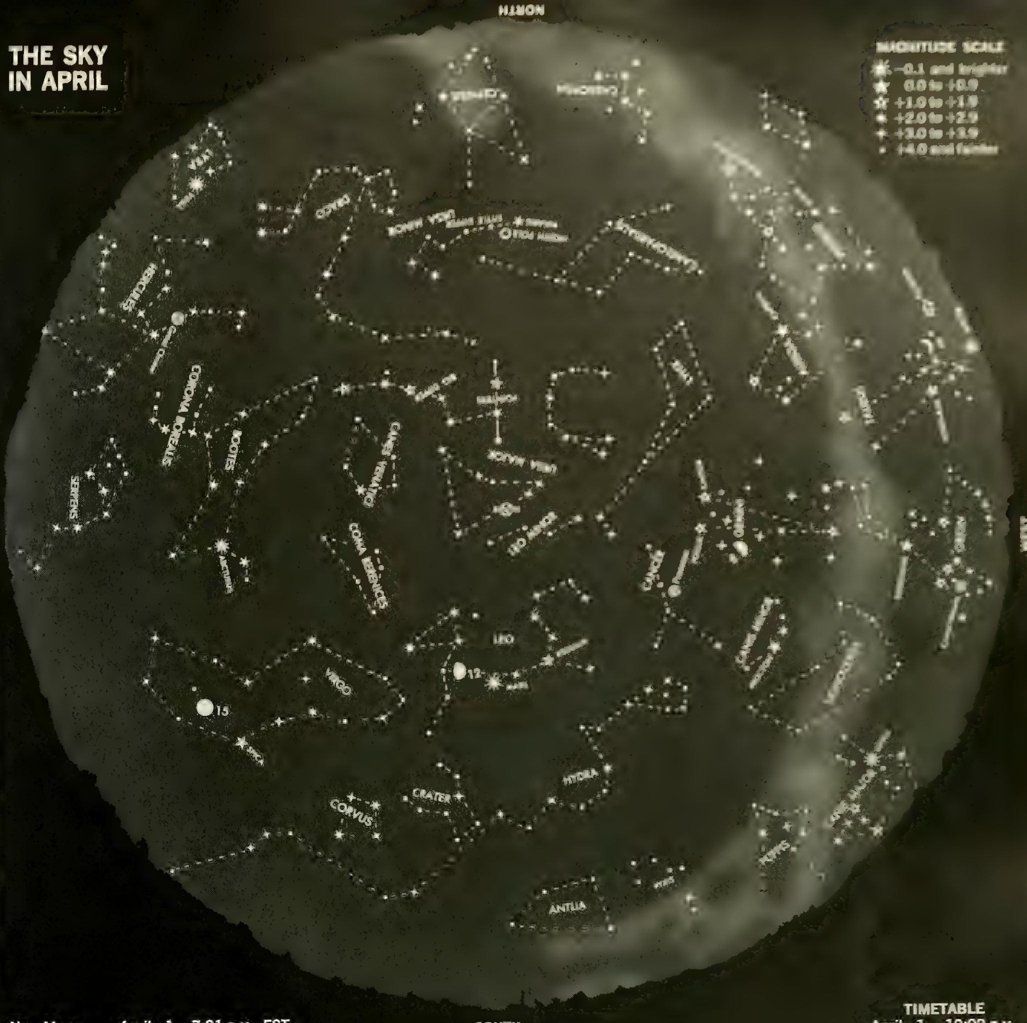
By the middle of June, Mars will be strictly an evening star, appearing in the south about sunset and setting by midnight. It will have then diminished to magnitude +0.7, and its distance will have increased to 114,200,000 miles. After that it remains an evening star for many months, continuing to fade in magnitude, setting progressively earlier each night. In late October, when it is 183,000,000 miles away, it will be at magnitude +1.4 and will set only three hours after the sun, again hardly of special note in the sky. Finally, it returns to conjunction with the sun on April 29, 1966—228,300,000 miles from earth.

EACH time it arrives at opposition during a synodic period (from conjunction to conjunction), Mars comes closest to the earth. But the distance from earth to the planet varies from one opposition to another because of the ellipticity of the Martian orbit and because the oppositions occur progressively at different positions around the orbit.

The point in Mars's orbit where it approaches the sun (and the orbit of earth) most closely is located in the direction of the stars in Aquarius. Should an opposition occur when earth and Mars are in that direction, Mars will then be in the part of its orbit closest to earth, and the distance between the two planets will be the least possible—about 35,000,000 miles. However, when earth is located on that side of its orbit (in the direction of Aquarius from the sun), it is late August in our calendar. This is why close, or favorable, oppositions always occur in our late summer.

The last opposition of Mars, which occurred near perihelion in the Martian orbit, was on September 7, 1956, when Mars came within about 35,120,000 miles of the earth. As we showed earlier, successive oppositions after that time must occur at points on the Martian orbit that are progressively 50 degrees farther east around the orbit. The seventh opposition will therefore be 350 degrees around the orbit to the east, or about 10 degrees west of the last favorable opposition. It will occur in August, 1971, when Mars will be about 35,000,000 miles distant. Each of the seven oppositions occurs at 780-day intervals, a total of about 15 years for the entire cycle, although the cycle may last 17 years if the eighth opposition proves to be the most favorable one.

# THE SKY IN APRIL


NORTH
MAGNITUDE SCALE
-0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
DRACO
URSA MINOR
HERCULES
CORONA BOREALIS
BOOTES
SERPENS
ARCTURUS
CANES VENATICI
COMA BERENICES
URSA MAJOR
LEO MINOR
CANCER
GEMINI
LEO
12
REGULUS
VIRGO
15
SPICA
CORVUS
CRATER
HYDRA
ANTLIA
CANIS MINOR
EAST
WEST
SOUTH

| | | |
|---|---|---|
| New Moon | April 1, | 7:21 P.M., EST |
| First Quarter | April 8, | 7:40 P.M., EST |
| Full Moon | April 15, | 6:02 P.M., EST |
| Last Quarter | April 23, | 4:07 P.M., EST |

**TIMETABLE**

| | |
|---|---|
| April 1 | 10:00 P.M. |
| April 15 | 9:00 P.M. |
| April 30 | 8:00 P.M. |

(Local Mean Time)

April 4: Jupiter and the three-day-old crescent moon are close together in the western sky after sunset this evening, with the moon some distance to the right (west) of Jupiter. They are in conjunction about 1:00 A.M., EST, on the 5th.

April 8: Mercury passes between earth and sun, at inferior conjunction, and enters the morning sky.

April 11-12: Mars is near the gibbous moon in the evening sky on these two nights. On the 11th, Mars is the bright red star to the east (left of the moon); on the evening of the 12th, Mars is to the west (right) of the moon. Conjunction of Mars and the moon occurs at 7:00 A.M., EST, on the 12th.

April 15: The full moon tonight determines the date of Easter this year. Actually, the paschal full moon (determined by ecclesiastical rule) occurs on April 16. The following Sunday, April 18, is celebrated as Easter Sunday

April 20: Mercury is stationary in right ascension and resumes direct (easterly) motion.

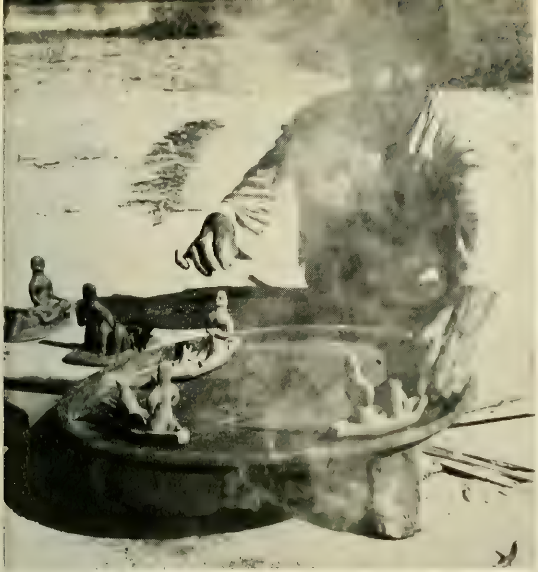
April 21: Mars is stationary in right ascension and resumes direct motion. It can be observed moving eastward among the stars of Leo from this night on. The Lyrid meteor shower, unfortunately for observers, reaches maximum at midnight tonight, but the last quarter moon will definitely interfere with viewing of the phenomenon.

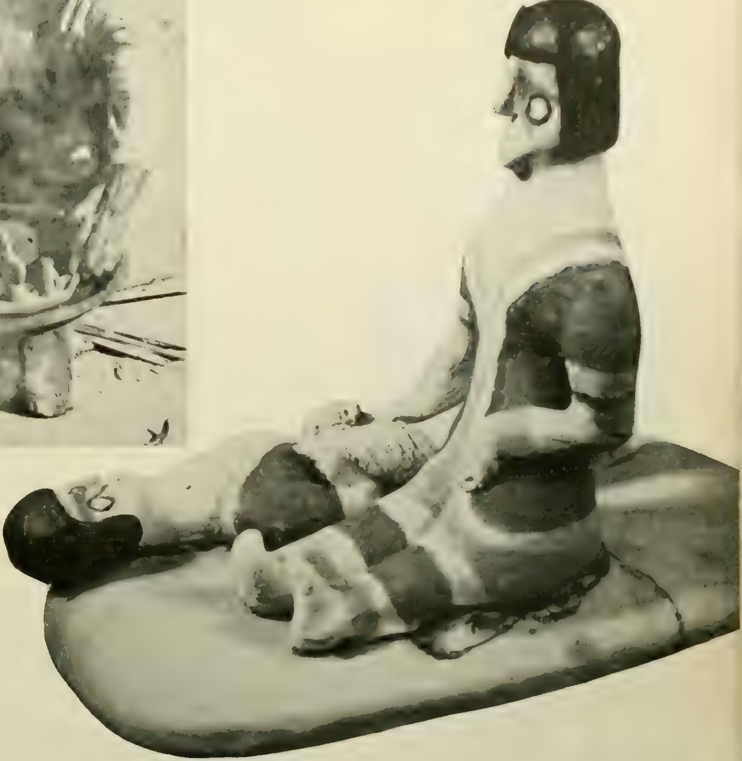
April 25: Many communities in the United States go on daylight time early this morning, the fourth Sunday in April. Clocks, in these communities, are set ahead one hour at 2:00 A.M. (Spring ahead, fall back.)

April 26: Saturn and the waning crescent moon are in conjunction at 10:00 P.M., EST, tonight. Saturn and the moon appear close together in the eastern sky tomorrow morning, just before dawn. The planet may be observed above and to the right of the moon.

April 29: Mercury, approaching greatest westerly elongation, is quite near the late crescent moon, low in the eastern sky very early today. Just as the moon rises this morning, look above and to the left of the moon at a distance of about four moon diameters. Mercury, a first magnitude object, is in conjunction with the moon at 6:00 A.M., EST. The sky is brightening rapidly, however, so you must have a clear easterly horizon and scan it with speed. Binoculars will be of help.

Photographs by Kurt Severin





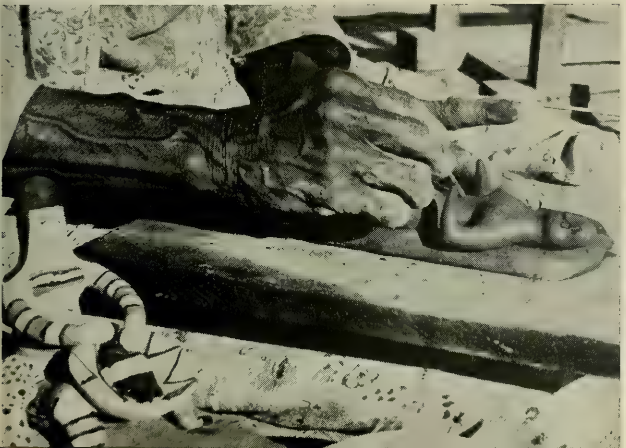
**Caraja potter** arranges clay figurines above a fire to bake them several hours.

**Dark circles** on cheeks of the figures at right represent Carajá ritual scars.

**Old woman**, *left*, moistens her fingers often to keep clay wet while working it.

**Fine stick** is used to impress rib and navel markings on figure of sick person.

# Figurines of the Carajá



The Caraja Indians of Central Brazil live in an area called the Ilha do Bananal, which is enclosed by two arms of the Araguaia River. The Carajá are adept at making small figurines, such as those shown here, of clay in which spicules of an indigenous fresh-water sponge are incorporated as a tempering agent. Painted mainly in black, red, and blue, the figurines are sought as souvenirs by visitors to the region, and the Carajá now produce them with an eye to the tourist market. In addition to representing people in various aspects of daily life, the Carajá also make their pottery in the shapes of those animals with which they are familiar.

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## About the Authors

Dr. Bobb Schaeffer and Marlyn Mangus, co-authors of "Fossil Lakes from the Eocene," are members of the scientific staff at The American Museum. Dr. Schaeffer is Curator of the Department of Vertebrate Paleontology, and Miss Mangus is a Scientific Assistant. Dr. Schaeffer, who is also a Professor of Zoology at Columbia University, received his B.A. from Cornell University and his doctorate from Columbia. His research interests include the vertebrate evolution and history of the fishes. Miss Mangus is a graduate of Vassar College and holds a master's degree from Columbia. Her work at The American Museum involves stratigraphy.

Dr. Jacques Bordaz, who wrote "The Threshing Sledge," is an Assistant Professor of Anthropology at the Graduate School of Arts and Science, New York University. Dr. Bordaz collected material for this article while conducting archeological field work at a Neolithic site near Seydisehir in southwest Turkey. He has written several articles for Natural History in previous years.

"Nesting of the Wood Stork" was written by George Heinzman and his wife, Dorotha, and was based on their four months of observing and photographing a Florida wood stork colony in 1961. Both are members of the Florida Audubon Society and have done field work in ornithology for many years. They are conducting a long-term study of the American bald eagle, and received the Florida Audubon Society's Conservation Award in 1962 for their efforts in forming the Kissimmee Co-operative Bald Eagle Sanctuary.

David Linton, author of the article on mirages, is a contributing editor to Natural History, and has written the camera column for many years. He is a well-known magazine photographer and has traveled widely. In 1954, on one of his many trips to the Arctic, he was able to photograph the mirages that accompany his article. "After a three-year search for the proper conditions," he says, "I photographed these mirages all in one day."

The author of "The Cross and Orb in Egypt" is John D. Cooney, who is Curator of Egyptian and Classical Art at the Cleveland Museum of Art. Mr. Cooney received his undergraduate education at Harvard College, did graduate work on Semitic languages at the University of Pennsylvania, and was in charge of the Egyptian collection in the Brooklyn Museum for almost thirty years. He is currently engaged in writing the history of the glass industry in ancient Egypt.

FRESH
as an
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august
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CRISP
as an
october
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**SCIENCE IN ACTION**

# Winter bark, slow fire

### By Dudley C. Lunt

"And standing faire alongst by the shore, about twelve of the clocke of the same day, we came to an anker, where sixe Indians in a Baske-shallop with mast and saile, an iron grapple, and a kettle of copper, came boldly aboard us, one of them apparelled with a waistcoat and breaches of blacke serdge, made after our sea-fashion, hose and shoes on his feet; all the rest (saving one that had a pair of breeches of blue cloth) were all naked."

So reads in part the record of Bartholomew Gosnold's voyage along the western coast of Maine as he trended southward in the little bark *Concord* in the spring of 1602. He continues,

"These people are of tall stature, broad and grim visage, of a black swart complexion, their eie-browes painted white; their weapons bows and arrows; it seemed by some words and signs they made, that some Baskes or [men] of St. John de Luz, have fished or traded in this place, being in the latitude of 43 degrees."

The significance of this account, one of the earliest about the Maine Indian, lies in the wealth of the detail that suggests earlier contacts between the white man and the Indian. The source of these is lost in the mists of the past.

The Indian of the Maine woods was a nomad. He was also a river man. He had his villages along the banks of the Saco, the Androscoggin, the Kennebec, the Penobscot, and a host of lesser streams. In the fall of the year and in winter he went upstream to hunt; in the spring of the year and in summer he paddled downstream to the coast to camp amid the wealth of shellfish and seafood with which the coast of Maine abounds. His birchbark canoe was his conveyance, and the waterways of the country of the Maine were his highways.

Without doubt that canoe is the Indian's outstanding contribution to modern America. His birch is a thing of the past, and the construction of the canoe is all but a lost art. But its lines, thwarts, gunwales, ribs, and planking are all to be seen in the canoe of today. A canoe is the proper craft for the man who hankers after an interlude on the waterways of the wilderness, and sleeps dreamless and content on a fir-bough bed.

The building of a birchbark canoe was a considerable undertaking. In Thoreau's time the Penobscots were adept at the art. At Old Town, Maine, in 1853 he watched old John Pennyweight at work on one that was nearly completed, and four years later, up on the West Branch near Northeast Carry, he came upon one in an earlier stage of construction. His account of the process in his *Journal* accords with the finding of later researches, the most notable of which is Fanny Hardy Eckstorm's detailed description. Her knowledge of the handicrafts of the Indians of Maine is unsurpassed, and to this source must go anyone who would have an authoritative account of this example of aboriginal woodcraft.

Winter bark was the first requisite; that is, bark that was taken from a canoe birch before the sap began to run. Old John Pennyweight went fifty miles upriver to the head of Passadumkeag, and there, says Thoreau, it took him "two days to find one tree that was suitable," that is, free of knots, burls, and blemishes for at least twenty feet. The birch was felled onto a cradle for the butt as well as the top. The trunk was then girdled at each end of the bark to be taken and a gash scored lengthwise along the trunk. Next came the careful peeling with wooden wedges, a process that was aided by the heat of a slow fire.

## Preparation of Bark

Mrs. Eckstorm paints an interesting picture of how the Indians got the bark out of the woods. The single sheet was turned over and rolled from the butt, with the inner side of the bark outside. This roll was lashed with cedar bark and lifted on a man's shoulders crosswise, with the ends sticking out on each side. With a tumpline that encircled the roll and came forward around his forehead, and another around his chest, the Indian would walk away with the heavy load.

The next step in the process was to roughhew the white cedar that would be needed for the gunwales, the ribs, and the lining or planking. Thereafter these and the thwarts, for which rock maple was sought, would all be fashioned with the ax and crooked knife, and the ribs would be steamed and bent to shape.

With these materials and a good supply of spruce roots—preferably white—all was ready for the construction. A spot was chosen in the shade of a tree, on hard and perfectly level ground near a stream, where the roll of bark would be soaked out. Thoreau watched a St. Francis Indian so engaged up on the West Branch, and his description of this stage of the work has the interest of a firsthand account.

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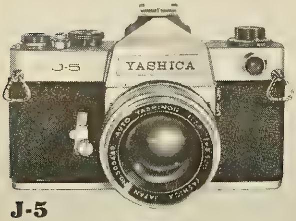

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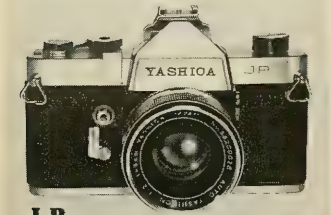

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Mr. Lunt's latest book is *The Woods and the Sea,*© Alfred A. Knopf, a work about the lore and yarns of the lakes, rivers, and rocky shores of Maine, from which this excerpt was taken.

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"As near as I could *see,* and *understand* . . . they first laid the bark flat on the ground, outside up, and two of the top rails, the inside and thickest ones, already connected with cross-bars, upon it, in order to get the form; and, with logs and rocks to keep the bark in place, they bend up the birch, cutting down slits in the edges from within three feet of the ends and perpendicularly on all sides about the rails, making a square corner at the ground; and a row of stakes three feet high is then driven into the ground all around, to hold the bark up in its place. They next lift the frame, i.e. two rails connected by cross-bars, to the proper height, and sew the bark strongly to the rails with spruce roots every six inches, the thread passing around the rail and also *through* the ends of the cross-bars, and sew on strips of bark to protect the sides in the middle. The canoe is as yet carried out square down at the ends, and is perfectly flat on the bottom. (This canoe had advanced thus far.)"

Next would come the lining and the fitting of the ribs, and then the ends would be finished, a task that called for great skill and care. In the extensive sewing, an awl made of bone or the tail of a horseshoe crab was used to puncture the birchbark for the entry of the spruce root. The sewing of the seams presented a crisscross pattern.

## Sealing with Pitch

THE last phase was pitching to make the canoe watertight. Before the combined use of grease and pitch was learned from the white man, spruce gum was used, the squaws doing the chewing. Pitching a canoe was an art in itself. The craft lay bottom up on a pair of horses. The pitch was heated in a pitch kettle and was applied to the seams with a flat stick and then worked in and shaped with the hands after they had been dipped in cold water. And so it was with the constant repairs necessary to keep this tender craft watertight.

The only decoration was a pair of eyes, a circle, or a star on each side at one end. This at once made that end of the double-ended craft the bow and, says Mrs. Eckstorm, "enabled the canoe to see the dangers and rocks ahead."

Such in rough outline was the aboriginal construction of a birchbark canoe, and the interested reader is referred to Mrs. Eckstorm's account in *The Handicrafts of the Modern Indians of Maine* for a most precise and meticulous description of this all-but-forgotten art.

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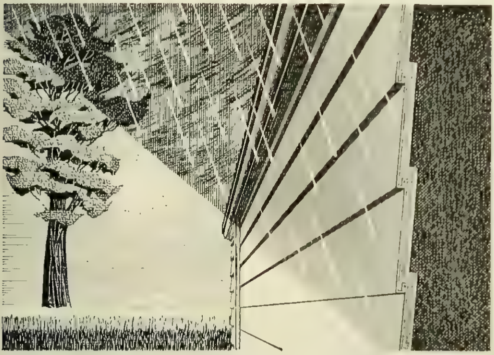

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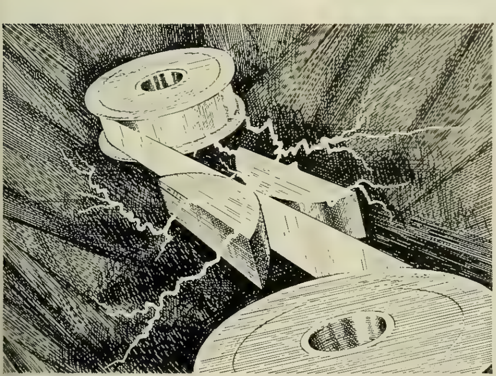

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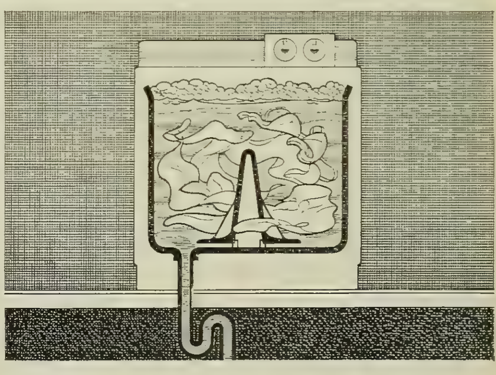

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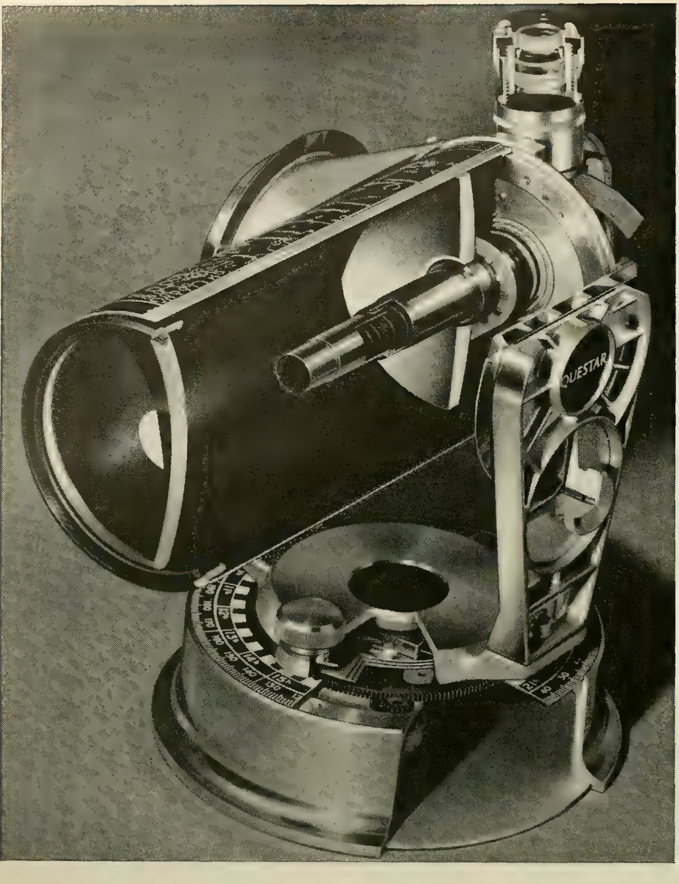

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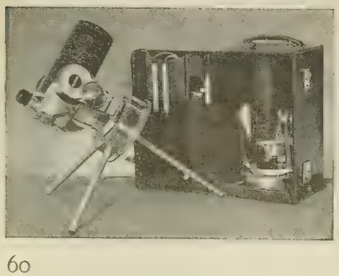

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# nature and the microscope

## hexagons, prisms, and cubes

### by Julian D. Corrington

WHEN the chemist or geologist unlimbers his microscope to embark on the study of crystals, rocks, or minerals, he will probably use an elaborate and expensive form of optical instrument, and his illumination will be polarized light. I plan to discuss these matters later, but there are certain elementary approaches to the microscopic study of crystals that the amateur microscopist, even with the simplest of equipment, may pursue with profit and enjoyment, and that should precede advanced work.

Crystals may be either inorganic or organic in chemical classification and, while non-living, they are organized, in the physical sense, and can grow. Of course, all matter is organized at the atomic level, but in our ordinary usage of this term, at visible and microscopic sizes, we may divide inorganic materials into the crystalline and the amorphous (without form). The latter exist as substances of indefinite and variable shapes, sizes, and amounts—as a shovelful of earth, a slab of rock, a glass of water, or a pot of glue. A crystal, on the other hand, is bounded by plane surfaces symmetrically arranged—the external expression of a definite internal structure—and appears as a cube, prism, hexagon, or other regular form.

These differences are well illustrated by the contrasting definitions of mineral and rock. A mineral is usually a solid at ordinary temperatures (the exceptions are mercury and water, which are classed technically as minerals). Minerals have a definite chemical composition, being either an element or a compound for which a regulation chemical formula may be written; for example, bauxite, the aluminum ore, is represented by the formula $Al_2O_3 \cdot 2H_2O$. Minerals occur naturally and almost always have a definite molecular structure expressed visibly as a crystalline form with specific

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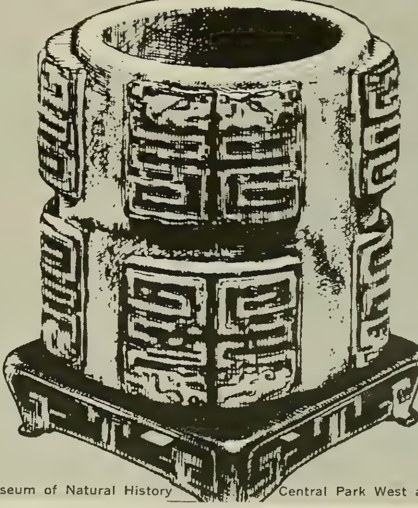

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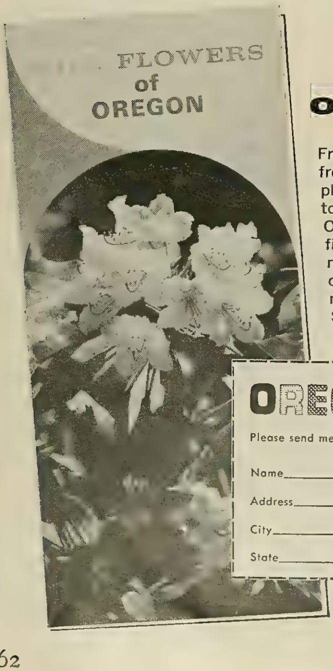

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optical properties. By a loose extension of the system used with animals and plants, they are grouped into such categories as classes, families, species, and the like. Commonly, their names end in the suffix *-ite*, as in halite for common salt (sodium chloride), or cuprite for native red oxide of copper, an important ore mineral.

A rock, by contrast, has no definite geometrical shape or size. It is a mass of mineral material in the earth's crust sometimes composed of a single mineral species, more often of two or more in a heterogeneous mixture. If a piece of granite is examined one may see the crystals of three different minerals mixed without any order in their arrangement —quartz, feldspar, and mica cemented together and commonly having impurities. Moreover, there are two kinds of feldspar and two kinds of mica; no chemical formula for granite could be written. Technically, a particle of clay or a grain of sand are rocks. These objects are also classified into taxonomic groups, and their names may also end in *-ite*, as granite and syenite.

## Methods of Studying Rocks

THE geologist uses both field and laboratory procedures in studying rocks. In the field he employs instruments to register the dip and strike of exposed beds of sedimentary rock. The dip is a measurement of the displacement from the horizontal position that all stratified beds originally occupied; it is the angular inclination of the bed from the horizontal. The strike is measured at right angles to the dip and is expressed as a compass direction. Thus a given limestone bed may be tilted up to an angle of 19 degrees from the horizontal, and its face may be directed NE. by N. Many other field data are recorded, then a specimen is taken into the laboratory. The rock is tested for hardness, color, luster, and the streak it makes on a plate of unglazed porcelain, often a different color from that of the mineral itself. This color variation occurs for the same reason that a pane of glass appears transparent, but when crushed is opaque white: the particles cause reflections and refractions not present in a uniform surface. The rock is also tested for specific gravity, form, cleavage, type of fracture when struck with a hammer, magnetism, taste, odor, and the effects on it of heat, water, and such reagents as hydrochloric acid. Water, for instance, will dissolve some minerals such as salt, but not quartz; HCl will dissolve limestone, but also will not affect quartz. These are the common analyses used in determinative mineralogy, and some of them can be applied to the rock as a whole. Detailed study involves making thin sections of the rock and inspecting them under

olarized light with a special form of
strument, the petrographic microscope.
Much can be gained, however, from
low-power examination of whole, small
ortions of various rocks. To prepare
pecimens, break rocks into pieces that
re roughly ¼- to ½-inch cubes. Wash
hese thoroughly in running water and
llow to dry. Now make a number of
nall containers, called cells, that are
emented to the center of blank micro-
cope slides. Plastic or glass tubing from
2 to ¾ inch in diameter can then be
ut into ½-inch lengths for this purpose
nd bone embroidery rings may be em-
loyed for small cells. Cardboard boxes
ne inch on a side can readily be made
ith the help of glue or adhesive tape.
lastic boxes with hinged lids and snap
nclosures, 1 by 1 by ¾ inch, may be
urchased from supply houses. What-
ver type of cell is made, paint the in-
erior with flat black paint. When it is
ry, affix a mineral or rock specimen
ithin its cell with a spot of household
ement. If the specimen is very small,
levate it from the cell floor on a small
yramid of cork, cement cork to cell bot-
om and when dry, cement the specimen
the cork. A lid should be used to pro-
ect the cell from dust when it is not in
se. The cells, in turn, are cemented to
he center of blank microscope slides.
If preferred, specimens may be affixed to the bottom of pillboxes that are painted black within and placed directly on the microscope stage for examination. Use low power and strong incident illumination.

The different kinds of rocks for cell mounting are too numerous to list. Any type with a variety of colorful mineral crystals will make an interesting exhibit. Also do not overlook the metals such as curved wires of native silver and bits of native gold. The following are among the minerals that will make for an attractive basic collection.

*Azurite*, monoclinic crystals composed of blue basic carbonate of copper, a copper ore and pigment.

*Malachite*, usually in the form of mammillary masses of concentric fibrous structure; green basic copper carbonate.

*Sunstone*, a variety of oligoclase, which is a triclinic soda-lime feldspar exhibiting schillerization, a bronzy luster caused by great numbers of minute, sparkling inclusions.

*Jamesonite*, gray, orthorhombic crystals with metallic luster, also occurs in fibrous masses; sulphantimonite of lead.

*Opal*, an amorphous silica; a mineral gel commonly deposited from hot or warm silica-bearing waters. Contains varying amounts of water; occurs in

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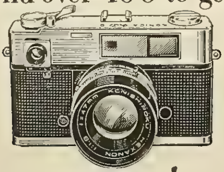

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amorphous masses. Precious opal, a gemstone, presents a peculiar play of delicately tinted colors.

*Opalized wood,* wood petrified with opal, showing the original grain.

*Garnet,* a complex silicate of many varieties, including green, yellow, brown, red, black. Some garnets are used as gemstones, others as abrasives.

*Cuprite,* cuprous oxide or red oxide of copper, appears as isometric crystals or in masses; important copper ore.

*Fluorite,* or calcium fluoride, a transparent or translucent mineral of many different colors, often very beautiful; commonly occurs in cubes, also tetrahexahedrons, and massive. Mineral is important for commercial uses.

*Galena,* chief lead ore, is a lead sulphide. Cubic or octahedral crystals or massive. Bluish gray with metallic luster, galena often contains enough silver to rank as a silver ore.

*Halite,* native salt, sodium chloride (see following experiments). Occurs in cubical crystals.

*Calcite,* calcium carbonate, hexagonal crystals. Occurs as limestone, chalk, marble, dogtooth spar, Iceland spar, stalactites, and stalagmites. May show nailhead crystals and butterfly twin formation; in many colors.

*Quartz,* or silica, $SiO_2$. Occurs in numerous crystalline forms such as amethyst, rock crystal, rose quartz, citrine, smoky quartz, tigereye, chalcedony, carnelian, chrysoprase, agate, jasper, and silicified wood.

## Crystallization

CERTAIN substances, such as chalk or sand, are insoluble in water. If fine chalk particles are stirred or shaken in a glass of water, only a mechanical mixture—a suspension—results. When sugar is stirred in a cup of coffee, however, a true physical solution occurs, the sugar molecules being dispersed through those of the water. Of a different nature is the electrolytic solution, in which a compound breaks down into its elements or combinations of elements in the phenomenon of dissociation. Thus when table salt is dissolved in water, the solution contains separate atoms of sodium and chlorine, called ions, but no salt molecules.

The quantity of salt that will break down in solution in a given amount of water varies with the temperature; hot water dissolves more salt than cold. Whenever the liquid has dissolved all of the solid possible at a given temperature, and there is an excess of the undissolved substance, the mixture is termed a saturated solution. If no solid is present, the solution may become supersaturated through the evaporation of some of the solvent, and if a solid crystal of the solute is then introduced, the excess of solute will be deposited upon it. Crystals

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*Dr. Gordon is the author of many books and articles on the ancient countries we are visiting. Among the books are ADVENTURES IN THE NEAREST EAST: THE WORLD OF THE TESTAMENT, and BEFORE THE BIBLE: THE COMMON BACKGROUND OF GREEK AND HEBREW CIVILIZATION. For many years he has taught the languages, history and archaeology of Egypt, Greece, and the Near East.*

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Dr. Corrington, who is well known in the field of microscopy, recently retired as Professor of Zoology at the University of Miami in Florida.

grow this way in nature and can be made to do so artificially in the laboratory—sometimes to a very large size. This growth is accomplished by accretion—the addition of new particles upon the surface of the older body. It is not true growth in the biological sense, but instead is like that of a snowball rolling downhill. Cells of animals and plants and whole organisms grow by intussusception, the addition of the new particles among the older ones.

There are two methods by which the microscopist may watch the process of salt crystallization under magnification. In the fusion method, a small bit of a solid salt is melted on a slide with gentle heat; crystal formation can be observed under the microscope as the liquid cools. Or you may make saturated solutions of a salt and watch crystallization by the solution method as the solvent evaporates or hot solutions cool. Try the latter with common salt; make a saturated solution in very hot water by pouring in salt and stirring until no more will go into solution. Then place two drops of this fluid on a slide. It is well to add a few sand grains upon which to secure a focus. No cover glass is needed. You will see cubes of solid salt pop up from the clear liquid right before your eyes—a startling experience. These crystals will form first around the edges where cooling and evaporation are most rapid. Try both low and high power and watch the crystals grow, noting the intricate pattern of etchings on the sides of the cubes, no two patterns being exactly alike. Repeat the entire process, using a cover glass. On a third slide, add two drops, then immediately spread the water into a film, using a warmed needle as a spreader. Examine at once, either covered or uncovered. Any of these methods work well.

Pyrogallic acid and hydroquinone, two reagents found in every photographic developing room, will make fascinatingly beautiful crystal designs. Household chemicals may also be used. Cream of tartar (potassium bitartrate) forms white crystals; tartaric acid, found in grapes, is an organic compound that lends itself well to a number of experiments. If the solution method is used, small and regular crystals appear, but by the fusion method the outcome is wholly different. Prepare by dissolving the acid in hot water and allowing it to crystallize out on a slide. Next melt some of this material on a slide and spread the resultant fluid into a thin film with a heated needle. Allow it to stand thirty seconds, then draw the point of the

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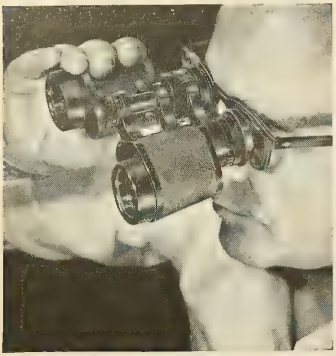

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needle through the film. Crystallization will start from this needle point and will assume a markedly different form—long monoclinic crystals. Now prepare a saturated solution in hot water. Place a few drops on a slide and keep warmed to hold in solution. In the center of this pool place a very small drop of a hot, saturated solution of bicarbonate of soda. When crystallization occurs, both chemicals will be seen, together with a third form—their compound—at the junction of the two. In place of bicarbonate, try Epsom salts (magnesium sulphate heptahydrate), Rochelle salt (sodium potassium tartrate), hypo (sodium hyposulphite or thiosulphate), borax (sodium tetraborate), and alum.

Another substance that behaves differently according to treatment is sulphur. Remembering that fumes of this element are noxious and, in large amounts, poisonous, slowly melt a small amount of sulphur in a porcelain dish or a cleaned "tin" can, then allow it to cool and solidify. Crystallization begins around the margin; when the edges are solid but the center is still liquid, pour off the central fluid. The crystals revealed in the marginal ring are pale yellow, transparent, long monoclinic needles which, unfortunately, are not permanent, passing into the next form within a few hours. Natural crystals of sulphur are rhombic octahedra, and are best prepared by the solution method, using carbon disulphide as the solvent. This solvent is highly flammable and explosive, so make sure that there are no open flames in the vicinity.

Crystals of organic compounds are the most elaborate in both pattern and color, and of these, hippuric acid has long been a favorite. To prepare, saturate in absolute alcohol, warm, then place a drop on a slide. For a permanent mount use castor oil or natural balsam; xylene balsam will not be satisfactory because xylene will dissolve hippuric crystals, whose delicate feathered bodies are representative of the beauty to be found in the microscopic examination of various rocks, minerals, and crystals.

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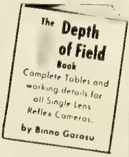

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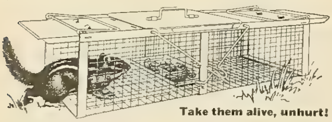

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# Suggested Additional Reading

## FOSSIL LAKES FROM THE EOCENE

LIMNOLOGY AND THE EOCENE LAKES OF THE ROCKY MOUNTAIN REGION. W. H. Bradley. *Bulletin of the Geological Society of America*, Vol. 59, pages 635-648, 1948.

STRATIGRAPHIC AND FACIES RELATIONSHIPS OF UPPER PART OF GREEN RIVER FORMATION AND LOWER PART OF UINTA FORMATION IN DUCHESNE, UINTAH, AND WASATCH COUNTIES, UTAH. Carle H. Dane. *Bulletin of the American Association of Petroleum Geologists,* Vol. 38, No. 3, pages 405-425, 1954.

STRATIGRAPHY OF THE GREEN RIVER FORMATION IN THE BRIDGER BASIN. Daniel A. Textoris. *Ohio Journal of Science,* Vol. 63, No. 6, pages 241-257, 1963.

## THE THRESHING SLEDGE

LIFE IN A TURKISH VILLAGE. Joe E. Pierce. Holt, Rinehart and Winston, N.Y., 1964.

SUR LE TRIBULUM. G. Luquet and P. Rivet. *Mélanges offerts à Mr. Nicolas Iorga par ses amis de France et des pays de langue française.* Librairie Universitaire J. Gamber, Paris, pages 613-639, 1933.

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FLIGHT INTO SUNSHINE: BIRD EXPERIENCES IN FLORIDA. Helen C. Cruickshank. The Macmillan Co., N.Y., 1948.

MYSTERIOUS MYCTERIA—OUR AMERICAN STORK. M. Philip Kahl, Jr., and Alexander Sprunt IV. *Audubon Magazine,* Vol. 62, No. 5, September-October, 1960.

FLORIDA BIRD LIFE. Alexander Sprunt, Jr. Coward-McCann, N.Y., 1954.

## MIRAGES

THE NATURE OF LIGHT AND COLOR IN THE OPEN AIR. Marcel G. J. Minnaert. Dover Publications, N.Y., 1954.

PHYSICAL OPTICS. R. W. Wood. The Macmillan Co., N.Y., 1914.

## THE CROSS AND ORB IN EGYPT

LATE EGYPTIAN AND COPTIC ART. J. D. Cooney. Brooklyn Museum, Brooklyn, 1943.

COPTIC SCULPTURE 300-1300. John Beckwith. Tiranti, London, 1963.

A SHORT ACCOUNT OF THE COPTS. William H. Worrell. University of Michigan Press, Ann Arbor, 1945.

A GENERAL INTRODUCTORY GUIDE TO THE EGYPTIAN COLLECTIONS IN THE BRITISH MUSEUM. A. F. Shore. British Museum, London, 1964.

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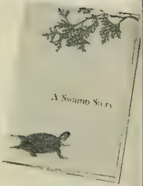

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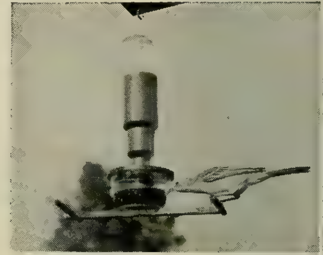


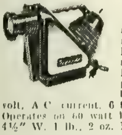
**FOR ORIOLES ONLY**

This unique new Oriole Feeder will attract man black-and-gold beauties to your garden. (Se unretouched photo.) Their colorful antics are true delight. A heartwarming gift for any occasion. Rustless, easy to clean. Money back guar antee, full instructions. Sorry no COD's. Pric $3.95 plus 32c postage. In Calif. add 16c tax Designed by Erwin M. Brown, Hummingbir Heaven, Dept. N, 6818 Apperson St., Tujunga Calif. (Also makers of the original and popula "Hummy-Bird Bar."®)

GET READY FOR THE SPACE and SCIENCE ERA! SEE SATELLITES, MOON ROCKETS CLOSE-UP

# AMAZING SCIENCE BUYS
## for FUN, STUDY or PROFIT

### Terrific Buy! American Made!
### OPAQUE PROJECTOR



Projects illustrations up to 3" x 3½" and enlarges them to 35" x 30" if screen is 6½ ft. from projector, larger pictures if screen is further away. No film or negatives needed. Projects charts, diagrams, pictures, photos, lettering in full color or black-and white. Operates on 115 volt, A.C. current. 6 ft. extension cord and plug included. Operates on 60 watt bulb, not included. Size 12" x 8" x 4½" W. 1 lb., 2 oz. Plastic case with built-in handle.

**Stock No. 70,199-E** **$7.95 Postpaid**

### FASCINATING NEW KALEIDOSCOPE INSERT

Same set as above, but provides endless additional projects with everchanging kaleidoscope patterns.

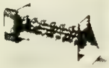
**Stock No. 70,714-E** **$10.00 Ppd.**

### KNOW WIND SPEED ANYWHERE, ANYTIME WITH POCKET WIND METER

Useful to all outdoorsmen, especially sailors, shooters, fliers, golfers. Lightweight Pocket Wind Meter accurate to within 1 MPH. Two scales—low and high velocity. One from 2-10 MPH graduated in ½ MPH increments. Second from 10-66 MPH in 2 MPH increments. Easily read even in inclement weather. 6⅝" long x 1½" wide x ⅝" thick. Wt. approx. 2 ozs. Plastic pocket carrying case. Instructions included.

**Stock No. 60,349-E** **$4.95 Postpaid**

### SOLVE PROBLEMS! TELL FORTUNES! PLAY GAMES!
### NEW WORKING MODEL DIGITAL COMPUTER
### ACTUAL MINIATURE VERSION OF GIANT ELECTRONIC BRAINS



Fascinating new see-through model computer actually solves problems, teaches computer fundamentals. Adds, subtracts, multiplies, shifts, complements, carries, memorizes, counts, compares, sequences. Attractively colored, rigid plastic parts easily assembled, 12" x 3½" x 4¾". Incl. step-by-step assembly diagrams, 32-page instruction book covering operation, computer language (binary system), programming, problems and 15 experiments.

**Stock No. 70,683-E** .. . **$5.00 Ppd.**

### AGES-OLD FOSSIL COLLECTIONS

Millions of years old! 3 full sets—30 fantastic plant and animal fossils—all for $3.75. EARTH SCIENTIST SET: Dinosaur bone, crinoid stem, horn coral, worm tubes, petrified wood, bryozoa stem, lamp shell, scallop, sea urchin, oyster, clam, snail fossil. CARBONIFEROUS SET: Brachipod, worm burl, crinoid stem, fusuline, horn coral, bryozoan, snail and clam. CRETACEOUS SET: Brachipod, oyster, sea urchin, pertified wood, etc. All three sets for one low price!

**Stock No. 50,344-E** ..... .... ...... **$3.75 Postpaid**

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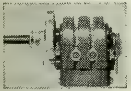
Fine quality, erect image zoom telescope, for naturalists and hobbyists. 50 mm hard coated, achromatic objective. Separate zooming and focusing adjustments. Field of view at 25X is 1-degree, 30 minutes; zooms to 0-degrees, 35 minutes at 80X. Magnification scale marked on eyepiece mount. High resolution over entire field. Excellent for both terrestrial and celestial observation. Includes sunglass for safe solar observation. 22½" long on sturdy 10" tripod.

**Stock No. 70,623-E** .. .. . **$35.00 Postpaid**

### WAR SURPLUS ELECTRIC GENERATOR



Brand new Signal Corps Electric Generator for scientific experiments, electrical uses, demonstrations. Generates up to 90 volts by turning crank. Use in high impedance relays. Charge ground and bring up night crawlers for bait or study. 2 Alnico Magnets alone **worth original price. Wt. 2 lbs.** Cost to Govt. $15.

**Stock No. 50,225-E** **....................$6.95 Postpaid**

**Same type generator, mounted, with light, as electricity** demonstrator

**Stock No. 50,365-E** **....................$11.95 Postpaid**

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**With this Kit, you can collect fluorescent rocks, paint with living light, write secret messages, learn invisible detection methods, even make a fluorescent Christmas tree! Kit uses longwave blacklight, which is completely harmless to eyes, but causes fluorescence in over 3,000 substances. Includes Magic Glow Lamp, universal laboratory lamp stand, invisible water paints and ink, fluorescent crayon, tracer powder, pen, 3 brushes, specimens of fluorescent rocks: wernerite from** Canada, fluorite from England, willemite from U.S.A. **Plus book of 40 experiments.**

**Stock No. 70,256-E** **....................$11.95 postpaid**

### BE READY FOR THE MOON SHOTS

Ranger, Surveyor, Lunar Orbiter [illegible] with [illegible] new light on [illegible] and outer space [illegible] top quality equipment [illegible] practical, valuable and complete information [illegible] on target

### See the Stars, Moon, Planets Close Up!
### 3" ASTRONOMICAL REFLECTING TELESCOPE

Photographers! Adapt your camera to this Scope for excellent Telephoto shots and fascinating photos of moon!

60 to 180 Power—Famous Mt. Palomar Type! An Unusual Buy!

See the Rings of Saturn, the fascinating planet Mars, huge craters on the Moon, Phases of Venus, Equatorial mount with lock on both axes. Aluminized and overcoated 3" diameter high-speed f/10 mirror. Telescope comes equipped with a 60X eyepiece and a mounted Barlow Lens. Optical Finder Telescope included. Hardwood, portable tripod. FREE with Scope: Valuable STAR CHART plus 272-page "HANDBOOK OF HEAVENS" plus "HOW TO USE YOUR TELESCOPE" BOOK

**Stock No. 85,050-E** **$29.95 Postpaid**

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**Stock No. 85-105-E** **$79.50 F.O.B.**

**Superb 6" Reflector Telescope**

Up to 576 Power Equatorial mount and Pedestal Base

**Stock No. 85,086-E** **$195.00 F.O.B.**

### *New! 2 in 1 Combination! Pocket-Size*
### 50 POWER MICROSCOPE and 10 POWER TELESCOPE

**Useful Telescope and Microscope combined in one amazing, precision instrument. Imported! No larger than a fountain pen. Telescope is 10 Power. Microscope magnifies 50 Times. Sharp focus at any range. Handy for sports, looking at small objects**

**Stock No. 30,059-E** . . ..... **$4.50 ppd**

### NEW BINOCULAR-TO-CAMERA HOLDER
### Will Fit Any Camera

**For Exciting Telephoto Pictures. Bring distant objects 7 times nearer with a 35mm camera. 7x50 binocular and** our NEW BINOCULAR-TO-CAMERA HOLDER. **Ideal for long-range shots of wild life, ships, people, vistas. Camera and binoculars attach easily.** Use any binocular or monocular—**any camera, still or movie. Take color or black and white. Attractive gray crinkle and bright chrome finish. 10" long. Full directions for taking telephotos included.**

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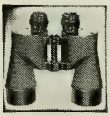
### NEW! STATIC ELECTRICITY GENERATOR
### Sturdy, Improved Model

**See a thrilling spark display as you set off a miniature bolt of lightning. Sturdily made—stands 14" high. Two 9" plastic discs rotate in opposite directions. Metal collector brushes pick up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping spark.** 24 page illustrated booklet included.

**Order Stock No. 70,070-E** . .. **$12.95 Postpaid**

### WAR SURPLUS! American-Made!
### 7x50 BINOCULARS



**Big saving! Brand new! Crystal clear viewing — 7 power. Every optical element is coated. An excellent night glass — the size recommended for satellite viewing. Individual eye focus. Exit pupil 7 mm. Approx. field at 1,000 yds is 376 ft. Carrying case included. American 7 x 50's normally cost $274.50. Our war surplus price saves you real money.**

**Stock No. 1544-E** **...................................only $74.80 pstpd.**

**7 x 35 AMERICAN MADE BINOCULARS**

**Stock No. 964-E** . **$60.50 pstpd.** (Tax incl.)

6 x 30 Binoculars—Similar to above and a terrific bargain

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12 Different puzzles that will stimulate your ability to think and reason. Here is a fascinating assortment of wood puzzles that will provide hours of pleasure. Twelve different puzzles, animals and geometric forms to take apart and reassemble, give a chance for all the family, young or old, to test skill, patience and, best of all, to stimulate ability to think and reason while having lots of fun. Order yours now

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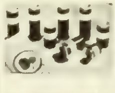
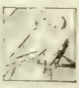


[illegible]

**Stock No. 70,[illegible]-E** **$[illegible] Postpaid**

### BIRDWATCHERS SEE WITHOUT BEING SEEN



The "one way" [illegible] always been [illegible] compared to [illegible] they are [illegible] from a few [illegible] away

**Stock No. 70,[illegible]-E a sheet 21" x 3[illegible]"** **$3.00 Postpaid**

### 'FISH' WITH A WAR SURPLUS GIANT MAGNET
### Bring Up Under-Water Treasures

**Real fun! Profitable, too! Simply trail this powerful 5 lb. Magnet** out the stern of your boat—retrieve outboard motors, fishing tackle, anchors, other metal valuables. Alnico V-Type Magnet has terrific lifting power—[illegible] Gauss rating—lifts over 150 lbs. on land—more under water. Many industrial uses, too, recover tools and parts from inaccessible spots, hold work in place, [illegible]

**Stock No. 70,571-E 5-lb. Magnet** **$12.50 Pstpd.**

**Stock No. 70,570-E 3½-lb. Lifts 40 lb.** **$8.75 Pstpd.**

**Stock No. 70,572-E 7½-lb. Lifts 175 lb.** **$18.75 Pstpd.**

**Stock No. 85,152-E 15¾-lb. Magnet Lifts 350 lbs.** **$33.60 FOB**

### THE WORLD OF DINOSAURS ONE HUNDRED MILLION YEARS AGO

**In this set of monsters—the dinosaurs that ruled the earth** 100,000,000 years ago—you get 17 realistic models molded **from unbreakable plastic. Collection includes the brontosaurus, dimetrodon, and others from the earlier species;** the tyrannosaurus and many more from the final eons of the dinosaur rule. Fascinating study for young and old; also novel as off beat decorations. Average size approximately 4" high. Kit includes ferns, trees, caves and other areas of terrain plus an exciting booklet **Prehistoric Animals.**

**Stock No. 70,473-E** **$4.95 Postpaid**

### HOME WEATHER STATION

New "Weather Station" is highly sensitive to weather changes. Consistently accurate thermometer to ± 2%; barometer accurate to ± .25" and hygrometer to ± 5%. Foretells weather changes from 12 to 24 hours in advance. Hygrometer calibrated in percent relative humidity. Excellent for teaching weather phenomena and meterological hobby work. Instrument mounted on handsome wood-grained wall panel 15½" x 5¾". Meter cases heavily metalized—combines beauty and protection. Dials, in etched aluminum, of high precision. Full instructions.

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**Science Treasure Chest**—extra powerful magnets, polarizing filters, compass, one-way mirror film, prisms, diffraction grating, and lots of other items for hundreds of thrilling experiments, plus a Ten Lens Kit for making telescopes, microscopes, etc. Full instructions.

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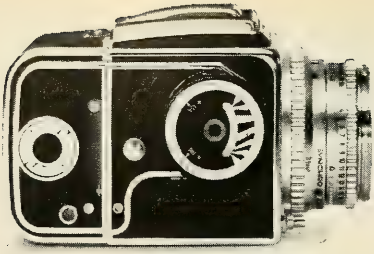
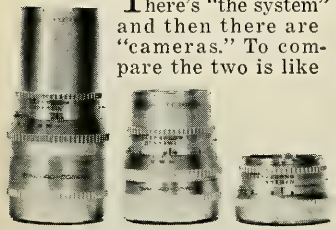


# When you talk about "the system" there's no brand X to compare it with.



*Left to right: Zeiss 250mm, 150mm, and 80mm lenses.*

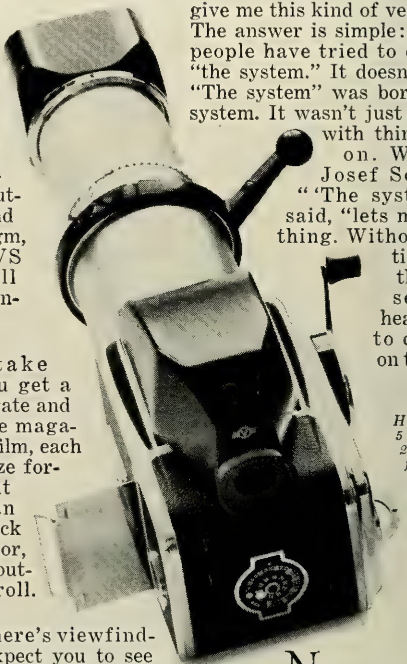
There's "the system" and then there are "cameras." To compare the two is like mixing apples and oranges. And certainly does "the system" an injustice. Because "the system" is more than a camera. It's a unique and complete combination of interchangeable components that offers more versatility, more optical excellence than anything called "camera."

*Josef A. Schneider, internationally famous photographer of children, was introduced to Hasselblad while taking a portrait of the Crown Prince of Sweden 15 years ago. He holds the unique distinction of being the first American photographer to use "the system" commercially.*

In the area of lenses, for example. "The system" doesn't have one or two or even three. The number is six. 50, 80, 120, 150, 250 and 500mm. Each one is precision-crafted Zeiss. Each has a Synchro-Compur shutter, automatic and manual diaphragm, and coupled EVS system. And all are completely interchangeable.

Now take film backs. You get a choice of 4 separate and interchangeable magazines. 3 for roll film, each in a different size format, one for cut film. So you can change from black and white to color, from indoor to outdoor film mid-roll.

Then there's viewfinders. We don't expect you to see every shot the same way. Your needs change, right? So do our viewfinders. "The system" gives you five. (Four more than you get on most "cameras.") Eye-level prisms, sportsviewers, magnifying hoods. And sunshades, filters, proxars, bellows, exposure meters, cases. You name it.



*Hasselblad 500C with 250mm lens, fast winding handle, eye-level prism finder, focusing handle and sunshade.*

Now you might say, "Aren't there any cameras that give me this kind of versatility?" The answer is simple: No. Sure, people have tried to duplicate "the system." It doesn't happen. "The system" was born to be a system. It wasn't just a camera with things added on. We asked Josef Schneider. " 'The system'," he said, "lets me do anything. Without limitation. I know that what I see in my head is going to come out on the film."

Now you know what we mean by "the system." Know it well. This is "the system," not to be confused with a "camera." For literature, write your dealer or Paillard Incorporated, 1900 Lower Road, Linden, N.J.

**HASSELBLAD**

# Natural History

May 1965 • 50¢

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Unusual Gifts from Ancient Worlds
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## THE CLEOPATRA LOOK!

Genuine Egyptian Scarabs served three purposes: as charms, seals, and for adornment. A small collection of ancient faience Scarabs has been set in modern Jewelry . . . *combining the artistry of 3000 years ago with Jewelry fashions of today!* Superb all-occasion gift in *Sterling* silver or 14K *GOLD . . . (displayed in rich Jewelry case)* f.t.i.

| | Charm | Pendant | Earrings |
|---|---|---|---|
| Silver | $17.89 | $19.89 | $27.79 |
| Gold | $19.89 | $24.89 | $37.79 |

MATCHING EARRINGS

## CLEOPATRA AGE JEWELRY

Ancient Egyptian faience beads (3rd Cent. B.C.—4th Cent. A.D., CLEOPATRA AGE), from excavated caches. *Entombed for centuries, these exotic, colorful beads in concert form a necklace treasure; a tasteful complement to casual or formal attire.*

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| 24 inch Necklace of ancient beads | $15.50 f.t.i. |
| Sterling Silver drop bead earrings | $ 5.75 f.t.i. |
| Complete Set: Necklace & Earrings | $19.75 f.t.i. |

FREE: Elegant display case with Necklaces & Earrings.

## BRONZE AGE ARROWHEADS . . . *

Excavated from famous archaeological sites in "AMLASH" (near the mts. of LURISTAN!) Bronze Arrows date from 15th-8th Cent. B. C. & exhibit rich malachite green patina! *Each arrow a magnificent display piece . . . unique*

| | |
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| SELECT Arrowhead 3"-5" | $6.50 |
| Average Arrowhead 2"-3" | $4.50 |

FREE: Plastic display stand for arrow

*SEE—"The Illustrated London News", May 5, 1962, P. 699-701

## EXOTIC COINS

. . . from the "sinister" gaming dens of Siam's 18th and 19th Centuries! Used as a means of exchange, these attractively fashioned porcelain coins reflect the simple beauty inherent in Oriental art. Now these very coins crafted with sterling silver make exotic all occasion jewelry. In addition, you can frame them creating a unique wall decoration.

| | |
|---|---|
| Siamese gambling porcelain coin, each | $1.75 |
| Collection of 6 different design coins | $7.90 |

| —HER JEWELRY— | | —HIS JEWELRY— | |
|---|---|---|---|
| CHAIN & PENDANT | CHARM | TIE TACK | CUFF LINKS |
| $7.95 | $5.90 | $5.90 | $9.50 |

# ANTIQUITY GIFTS...

## TEMPLE BUDDHAS . . .

*(from 18th-19th Cent. Siam)*

Secured from abandoned vegetation overgrown, timeworn temples deep in the primeval forests of northern Siam. Superbly crafted teakwood statuettes, lacquered red &/or black . . . *several Buddhas richly finished in Gold leaf, some with hand inscribed prayers!* Stately display (7"-10") complimenting home & office decor. A distinctive all-occasion gift! CHOICE Buddha, rich Gold leaf finish & inscribed prayers .......... $35.
Select Buddhas, rich Gold leaf $25.

## PRE-COLUMBIAN DISCOVERY!

*over 2000 Years Old . . .*

busts & torsos from the Valley of Mexico's primitive Indian culture dating from before the Birth of Christ. Masterful artisans crafted these mysterious clay figurines, early examples of *pestellaje* technique (applied features) used in pre-classic American art. Approx. 1¾" high, attractively mounted on walnut base, *these ancient creations make fascinating museum-like displays for home or office.* Unique gift idea!

| | |
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| SELECT Specimen, mounted | $12.75 |
| Average Specimen, mounted | $ 9.75 |

## ANCIENT OIL LAMPS

*over 1364 Years Old . . .*

Now available for display in your home or office! Actually excavated in Ancient Palestine, they date from 4th-7th Cent. A.D. You can rekindle lamp's ancient glow with wick and vegetable oil. Lamp symbolizes knowledge! *Will stimulate thought-provoking conversation. A superb all-occasion gift to be admired forever!* Lamp on hardwood base with parchment certificate of authenticity . $17.00

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## OSIRIS, KING OF THE GODS

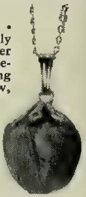
Osiris, the King of the gods, was according to Plutarch a wise and good ruler of Egypt. His life was spent improving the conditions of his subjects and the same for the other nations of the world. He was the husband of Isis, "King of the Gods," "Lord of Eternity" and the judge of the dead. He was considered the ideal father and Isis the faithful wife. The bronze figurines, 2½" to 3½" in height, belong to the XXVI Dynasty (663-524 B.C.) and the Ptolemaic period (332-30 B.C.).
OSIRIS Bronze figurine on handsome display mount .............................. $35.00

## COIN OF INDIA

The heavy silver coins of the Shah Jahan Empire (1632-1653) have been transformed into magnificent handcrafted jewelry. This famed Indian ruler built the Taj Mahal, the worlds most sumptuous memorial to a beloved wife. Coins of Shah Jahan, historically symbolizing his immortal love for the Empress Mahal, are now available as regal charms, pendants & cufflinks. *A gift truly expressing eternal love!*

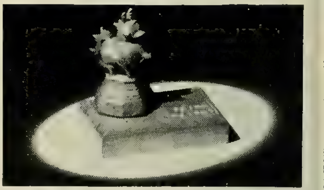
| | |
|---|---|
| Silver coin pendant | $23.50 |
| Silver coin charm | $19.50 |
| Silver coin cufflinks | $28.50 |

## ¼ BILLION YEARS OLD . . .



animal fossil (blastoid) frequently called "Sea Bud," actually lived over 230 million years ago. Nature's design, five vents surround center giving the blastoid a futuristic look. Now, this fantastic fossil has been crafted with sterling silver, creating unique jewelry . . . while remaining an alluring scientific curio! *Give as intriguing gift from "The Dawn of Life on Earth"!*

| PENDANT | CHARM | EARRINGS |
|---|---|---|
| $6.95 | $4.95 | $9.95 |



## *Miniature* OPIUM WEIGHTS

The sale of opium in 17th-19th Cent. Siam & Burma was state controlled. Used to weigh opium, these stylized bronze lions, ducks & elephants, handsomely mounted on walnut bases (or lucite) are approx. ½" to 1" high, weighing approx. 2/5 to 1 oz. Useful & unique as paperweights, they make an exotic addition to all collections . . . *a most intriguing gift from the Orient!*

| | |
|---|---|
| Opium Weight, ½" high, walnut base | $5.89 |
| Opium Weight, 1" high, lucite base | $9.50 |

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Vol. LXXIV MAY 1965 No. 5

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COVER: Eric Leshan, seen here, is a student at Pacific High School in Palo Alto, California. With a biology teacher and other students, he has made three trips into Mexico to examine the flora and fauna of a Sonoran sabino grove. This spring-fed "ecological island" was chosen for special study because of its unusual situation in the midst of a semiarid short tree forest. The article that begins on page 14 was written by the students themselves and reveals the depth of knowledge that teen-agers can achieve when they explore an environment and take notes of what they see. All the photographs were taken by Jesse Alexander.

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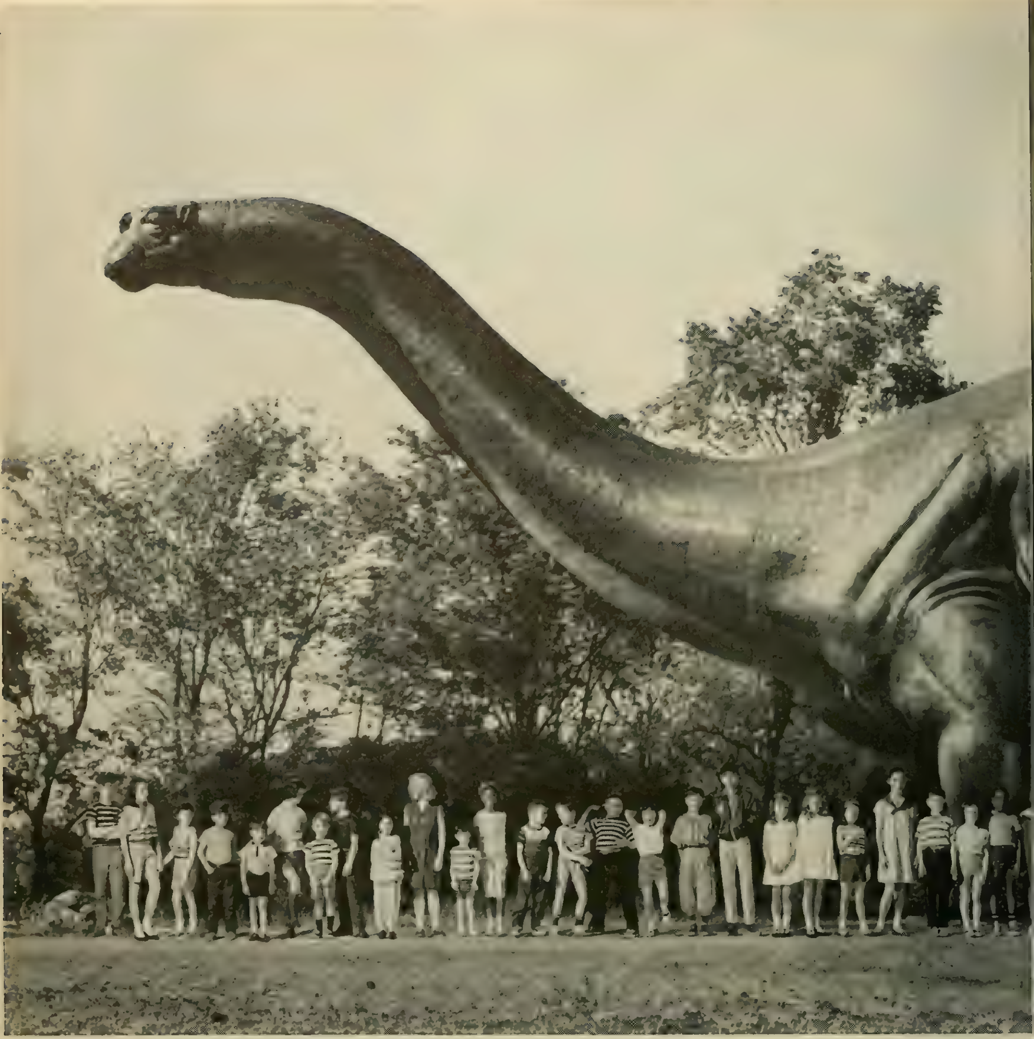

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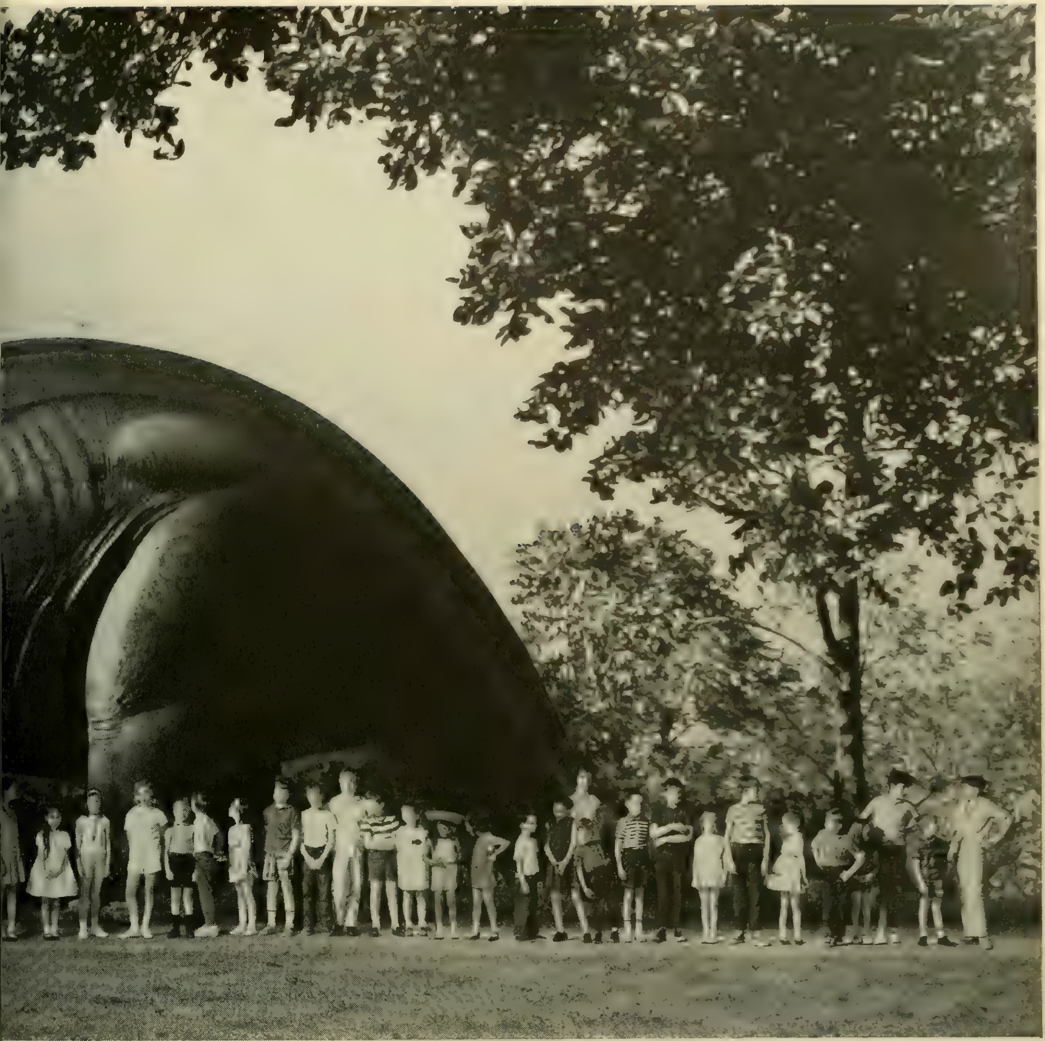

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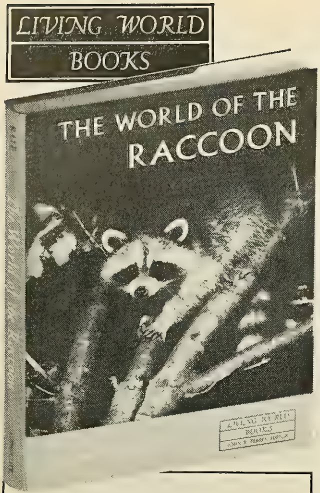

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**BOOKS IN REVIEW**

# Man against the insects

### By Robert Cushman Murphy

Pesticides and the Living Landscape, by Robert L. Rudd. *University of Wisconsin Press, $6.50; 320 pp.* Beneficial Insects, by Lester A. Swan. *Harper & Row, $7.95; 429 pp., illus.*

These two volumes would have delighted Rachel Carson, whose *Silent Spring* (1962) revolutionized the thinking of the world. Her book was at first belittled and even reviled by the manufacturers of pesticides. One official spokesman of a huge chemical industry publicly called it a "hoax." But as calm and authoritative opinion rallied to Miss Carson's thesis, the antagonists subsided, first to a semblance of courtesy and later to a realization that their entire stance needed reconsideration.

Dr. Rudd's work is the best kind of appraisal of the great bomb of publicity that burst three years ago. Supported by the Conservation Foundation, the author had freedom to write exactly as his investigation led him. His consideration of the subject fits into a fivefold frame: (1) how man, the so-called ecological dominant, exploits the living environment; (2) how he combats organisms that challenge his exclusive interests; (3) how successful he is in controlling these competitors; (4) the methods he uses in control; (5) the price he has paid for his practices.

Six chapters cover the history of the dilemma, the responses of a wide variety of organisms to pesticides, the human hazards, changes produced in the biological landscape, and the place of pesticides in the food chain, leading to delayed expression of objectionable results. An appendix incorporates the recommendations of President Kennedy's Scientific Advisory Committee on the Use of Pesticides, and there is an excellent bibliography.

Man, of course, builds up the populations of his pests by his simplification of complex environments through planting pure stands of a crop over large areas. He thus rejects a balanced fauna and flora of thousands of mutually competing species in favor of one or a few species specially adapted to subsistence on his harvests. We have been altering environments at a pace that precludes our understanding of what we are doing.

Rudd minces no words in confirming that millions of birds have been killed by DDT, and that the fire ant campaign of the U.S. Department of Agriculture was a fiasco. Despite such findings, the 1964 Yearbook of the Department flatly states that DDT has no serious effects on wildlife populations. Just how far can mulishness go?

After noting that perspective in chemical control has been lacking for the past two decades, Rudd strongly emphasizes the importance of biological control, which has proved to be the only reasonable solution of the Japanese beetle problem and a number of others. This leads directly to Lester Swan's book.

*Beneficial Insects*, a 429-page volume, is an eloquent and convincing plea for integrated pest control in which predators (including vertebrate animals), parasites, weed eaters, bacteria, viruses, yeasts, fungi, and other infectious organisms share a role with control by "artifice." The last represents such procedures as the sterilization of male insects, the synthesis of sex attractants as bait, light-attractant traps, mechanical barriers, repellents (odors, sounds, and high-frequency electrical fields), resistant strains of crop plants, the encouragement of parasites, and much more. Effective case histories are cited.

We used to be told that only about two hundred species of insects in all the world are seriously injurious to man. Today, the reckoning may be higher, but it is still an infinitesimal percentage of the insect fauna. Instead of the "million" species commonly mentioned, the existing species probably exceed five million. Professor Brues, of Harvard, presented strong evidence on that a score of years ago. From man's point of view, most insects are either neutral or beneficial.

Dr. Swan's accounts of the habits and life history of insects that are inimical to other insects provide fascinating and eye-opening reading. What we evidently need to keep our agriculture and stock raising in balance with the rest of the environment is as many *kinds* of insects as possible, rather than the largest *numbers* of only a few kinds. As D. A. Chant says in the Forward, "Pesticides are merely temporary palliatives, not permanent solutions. . . ."

*Dr. Murphy, Lamont Curator Emeritus of Birds at The American Museum, is also a well-known zoologist and author.*

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Animal Communication, by Hubert and Mabel Frings. *Blaisdell Publishing Co., $2.50; 204 pp., illus.*

Communication between animals involves the giving off by one individual of some chemical or physical sig-

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reptiles and amphibians
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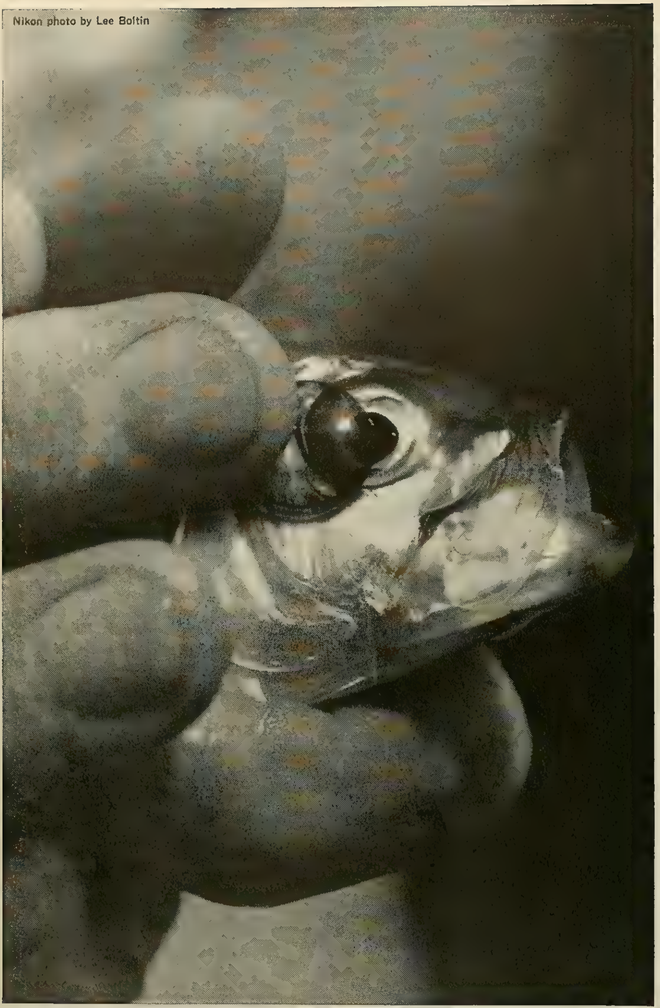

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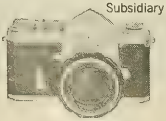

nal that, on being received by another, influences its behavior." With this basic, operational, and objective definition, Dr. and Mrs. Frings have reviewed a major area of interest in animal behavior. Their examples were chosen carefully from the gamut of animal forms, with special emphasis on invertebrates, and arranged in categories according to function: species identification, social co-operation, sexual attraction, courtship, and parental care. Chapters on the mechanisms of production of signals, methods of behavioral research, and evolutionary significance of communication are included. Some examples of communication are described in detail, such as odor trails in ants and guidance dances in bees, but the small size of the book and the vast scope of the field made it necessary to reduce other examples to brief statements.

In attempting to limit the coverage, the authors emphasized communication within species, and excluded so-called incidental signals, such as feeding sounds or non-specific odors, that are not produced by specialized structures. Inevitably, many instances of inter-species communication do crop up and "incidental" signals often play an important role in behavior. In order to be effective, communication signals must be readily separable from any background sounds, colors, smells, and so forth. Signals can be distinguished by their intensity, quality, or temporal patterning. The Frings show how this basic fact has influenced the evolution of signaling and receiving devices.

These two biologists are eminently qualified and knowledgeable in their field. Their writing style is clear, concise, and well organized—and they have included a good bibliography and index.

This is an excellent example of communication in itself, and demonstrates that scientists are capable of producing a readable and factually accurate exposition for the educated layman.

William N. Tavolga
*The American Museum*

Theory and Method in Ethnomusicology, by Bruno Nettl. *The Free Press of Glencoe, $5.95; 306 pp.*

Bruno Nettl's *Theory and Method in Ethnomusicology*—far more readable than its title might suggest—tries to set the young discipline of ethnomusicology on its feet by formulating a common theoretical background and method of approach.

Nettl defines ethnomusicology as the study of music outside the realm of Western civilization—a field belonging to, but neglected by, musicologists and anthropologists alike. The author then formulates a background of theory and method and discusses, clearly and pertinently

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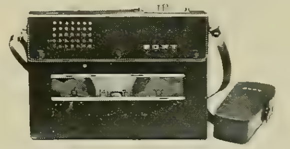

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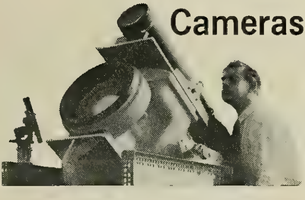

Scientists Who Work With Cameras

**By Lynn and Gray Poole**

From the depths of the sea to the far reaches of the universe, the camera is extending man's knowledge. This book describes the careers and work of twelve scientists who explore with the camera: strobe light investigator Edgerton; astronomers Whipple, Schwartzschild, McCrosky, and Davis; botanist Alexopoulos; radiologist Morgan; ultra-high-speed-action photographer Courtney-Pratt; space and undersea explorer Lee; laser light experimenter Ellis; moon searcher Edson; and earth mapper Shrader.

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the problems and techniques of field work and of transcription. He spends some time elaborating on the nature and description of style, and it is at this point that the reader who lacks musical training might feel out of his depth.

In the section dealing with musical instruments, Nettl broadens the field to show his concern with the close interrelationship between ethnomusicology and anthropology, and treats music in its widest social context.

Ethnomusicology has "only begun to scratch at the surface of its possibilities," says Nettl, but "music the world over is more than artifact . . . it is, even in the simplest cultures, an essential part of human life."

COLIN M. TURNBULL
*The American Museum*

THE GLORY THAT WAS GREECE, by J. C. Stobart, revised by R. J. Hopper. *Hawthorn Books, Inc., $10.95; 265 pp., illus.* THE ETRUSCANS, by Emeline Richardson. *The University of Chicago Press, $7.95; 285 pp., illus.*

An old friend makes its appearance togged out in fresh garments. The first edition of *The Glory That Was Greece*, a cultural appreciation of the Hellenic spirit from its emergence in prehistory to its conquest by Rome, was published in 1911. While excising some minor infelicities, the new editor, R. J. Hopper, had as his main task the integration of a vast amount of new material, only recently available to the historian, without losing the style and flavor of Stobart's original writing and thinking. The pictures and drawings of the earlier editions were completely replaced by excellent photographs. A new bibliography provides the curious reader with a fine selection of the latest scholarly but popularly written books, in which he can read in greater depth after this spectacular summary.

In some ways it is now a curious book. In it the latest reports to be drawn from Minoan-Mycenaean Linear B—from the new grave circle at Mycenae and from the fresh excavations in progress in Turkey—are coupled with quaintly archaic notions of the upward progress of mankind, and with delightful Victorian propriety: "There is no truer sign of civilization and culture than good sanitation." But Stobart's book remains, after half a century, a fine summation of a marvelously rich people. We must beware, however, of Stobart's idea of *telos*—that the pattern of history is characterized by an aim for perfection. We also must forgive his utter devotion to the Hellenic ideals that his generation, although perhaps not the Greeks themselves, worshiped.

Unlike the Greeks and their more ambitious neighbors, the Romans, the Etruscans did not leave behind an exten-

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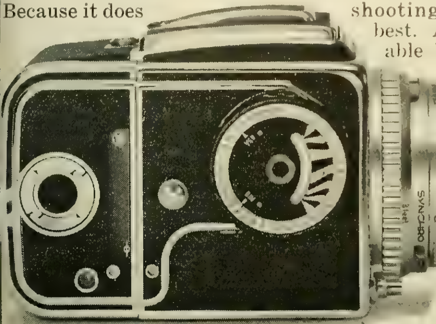
# Is Jerry Schatzberg part of "the system"? Or vice versa?



We don't really know. But let us explain. "The system" we refer to is the Hasselblad system. And it offers the photographer a unique and complete combination of interchangeable components that allows for greater versatility than anything called "camera." Because it does more, photographers depend on it more. To the exclusion of "cameras." And after a while we wonder whether they become part of it, or it of them? We asked Jerry Schatzberg.

"Yes, I've gotten to depend upon 'the system,'" he said. "It's versatile enough to minimize my need for anything else. When you're on the job you just can't lug around anything extra. 'The system's' got it all. Like six interchangeable lenses. When you've got 50, 80, 120, 150, 250, and 500mm lenses, there's nothing you can't take. And when they're all Zeiss, with manual and automatic diaphragm, and coupled EVS system, you know you're shooting with the best. And interchangeable backs. If I didn't have 'the system,' I'd have, say, three or four cameras loaded with different film. Not for me. 'The system' has 4 interchangeable magazines, 3 for roll film, one for cut film. So I can go from color to black and white, indoor to outdoor film, mid-roll.

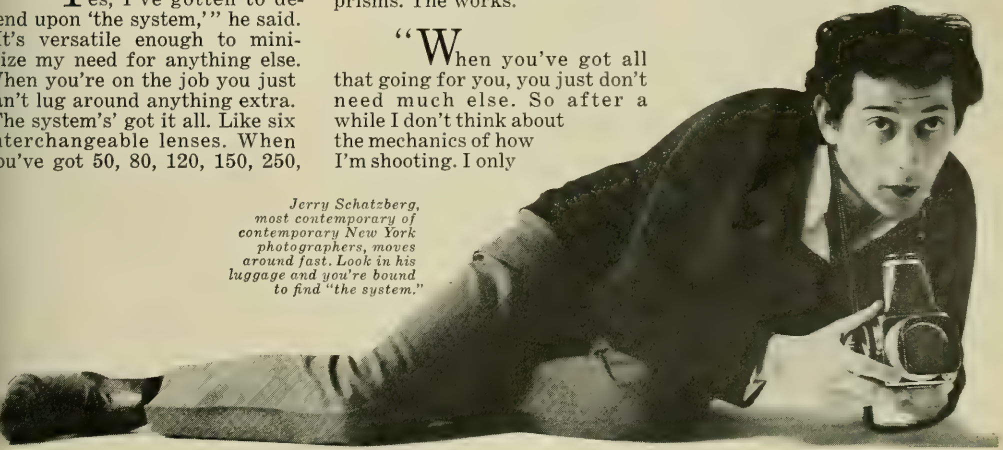
"Viewfinders, too. 'The system' lets me see the shot the way I want to see it. (Not any one set way like with 'cameras.') It gives me a choice of eye-level prisms, magnifying hoods, reflex prisms. The works.

"When you've got all that going for you, you just don't need much else. So after a while I don't think about the mechanics of how I'm shooting. I only think about shooting. You might say 'the system' becomes an extension of myself."

*[illegible] [illegible] [illegible] eye-level prism finder, 250mm lens, magnifying hood and film magazine.*

There's our answer: "The system" *does* become part of Jerry Schatzberg. It never gets in the way of the picture. It leaves the photographer free to see, to feel, to shoot. Take 5 cameras out with you. See how much or how little they get in your way. You'll let "the system" become part of you. For literature write: Paillard Incorporated, 1900 Lower Road, Linden, New Jersey.

**HASSELBLAD**



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sive literature on their virtues, history, and heroes. In the absence of such writings, the Etruscans have become one of those mystery people that archeological journalists—the buffs of lost Atlantis and white queens of the jungle—delight in dramatizing. Mrs. Richardson demonstrates in *The Etruscans* that she knows too much about the subject to indulge herself in the excesses of historical romance. With a fine hand, a sense of wit, and keen appreciation, she has written a no-nonsense book that is a primer on the culture of these early Italians. Drawing upon her firsthand knowledge of the land, the monuments, and Etruscology, she provides a solidly based account of the history of a people who flourished in those dim centuries around the middle of the first millennium B.C.

We know the Etruscans best from the obviously biased accounts of their covetous neighbors, the Romans, and from the furnishings of their tombs. Fortunately, the Etruscans did not take death lightly, but built their dead elaborate underground homes with muraled walls and sculptured details and left with them their most-prized furniture and personal belongings. However, from such slender evidence only a spotty, largely hypothetical history can be organized. If Mrs. Richardson offers no startling new suggestions about the origins of the Etruscans, she does provide a readable book that makes a fine gift for the person who asks, "Who were the Etruscans?"

BERNARD GOLDMAN
*Wayne State University*

TROPICAL AQUARIUM FISH, by A. van den Nieuwenhuizen. *D. Van Nostrand Co., $15.00; 200 pp., illus.* THE BOOK OF EXOTIC FISH, by R. and M. L. Bauchot. *Stein and Day, $8.95; 95 pp., illus.*

TWO new books on tropical fish in living color have arrived. A. van den Nieuwenhuizen's volume is a personal and beautifully illustrated account of some of the author's many and exceptional accomplishments as a skilled aquarist. The numerous photographs are by the author, and their artistic qualities and unusual sharpness mirror his enthusiasm for his subjects.

The book has been written on the charming premise, implicit on every page, that the reader will want to share the author's moments of success. Thus we see photographs of a particularly handsome pair of fish that have reproduced and are rearing their young; a less common species is seen performing its courtship and display rituals and defending its small territory in the author's aquarium.

In addition to the personal quality of the writing (some of which must certainly have been lost in translation from the original Dutch), an infusion of

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scholarly information is evident: in the general summaries of a species' occurrence in nature, in the comparisons of the behavior of related fishes, in the dates and circumstances of a fish's introduction into the aquarium trade, and in the brief. formal statements at the end of each section on the geographical distribution and on the derivation of scientific names of the various species described. There is no table of contents but there is an adequate index.

A few technical errors are made. chiefly in the orthography of scientific names. These should not lessen the book's desirability, but the price might. Fifteen dollars could well be out of the range of the largest group of potential readers—the many and enthusiastic small-aquarium hobbyists.

The companion book of this review. R. and M. L. Bauchot's *The Book of Exotic Fish*, was also translated (from the French), also has many colored illustrations, and is also overpriced. The text, apparently written in earnest and aspiring to great heights of ichthyological wisdom, is utter nonsense. The information so intensely imparted is frequently wrong—in general and in many particulars. The misspellings, incorrect usages, and orthographic horrors seem endless. Feeble in content, unattractive in printing and format, and repetitious in illustrative material, it is a volume to be scorned.

DONN E. ROSEN
*The American Museum*

STANDING UP COUNTRY, by C. Gregory Crampton. *Alfred A. Knopf* and *University of Utah Press, $15.00; 191 pp., illus.*
TIME AND THE RIVER FLOWING: GRAND CANYON, by François Leydet. *Sierra Club, $25.00; 173 pp., illus.*

FOUR months and three days after the Declaration of Independence was signed, a group of Spanish explorers finally made their way across the Glen Canyon of the Colorado River on their way back to Santa Fe, New Mexico, after attempting to find a good route to Monterey, California. They had suffered from cold and near starvation. Father Escalante, an expedition priest, wrote in his journal that they celebrated their river crossing "by praising God our Lord and firing off a few muskets as a sign of the great joy we all felt at having overcome so great a difficulty."

Since the days of Escalante many people have reached the banks of the Colorado, and many journals, articles, and books have been written about this fantastically eroded land. Two of the latest are *Standing Up Country* and *Time and the River Flowing: Grand Canyon.* They might be considered companion books. Crampton defines his "standing up country" as that area of

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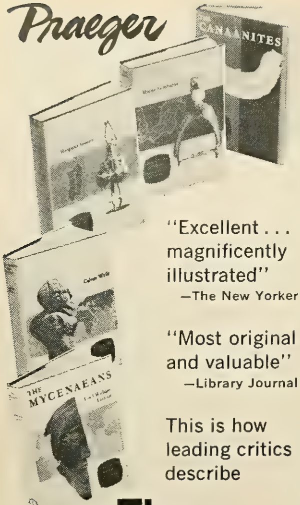

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the Colorado River drainage from Book Cliffs in Utah, on the north, to White Mesa and Lee's Ferry in Arizona, on the south. Leydet describes the Grand Canyon from Lee's Ferry to Lake Mead.

Both are marvelously illustrated. Crampton uses black-and-white and color photographs to show the bigness and the barrenness of "slickrock wilderness"—a local term referring to the Navaho sandstone in this area of the Southwest. Since relatively few people have flown over the land he describes, the air views add a new and interesting viewpoint. The photographs in Leydet's book are all in color, beautifully reproduced. Here again numerous views show the country's magnitude, but there are also many close-ups. The pictures of the patterns found in small sections of the canyon walls, in flowers, sand dunes, and small secluded pools serve as a forceful reminder that even in the presence of these gigantic, towering canyon walls we can also find beauty in microcosms.

Crampton, in the preface, calls his book the first comprehensive story of the Canyonlands area. It covers the geology, geography, prehistoric Indian life, the early Spanish explorations and trade routes, Mormon settlements, ranching, and mining. For a detailed understanding, however, one will have to rely on his bibliography and much more reading.

Leydet's book, on the other hand, is in the series of Sierra Club publications designed to promote their brand of conservation—"Let's leave our wilderness areas entirely alone." His description of his boat journey through the Grand Canyon is well written. From it he slips effortlessly into the geography, geology, wildlife, botany, and history of the Canyon. At first the text is interspersed with short arguments against further developments on the Colorado River. Soon the arguments become more frequent and longer until finally they comprise most of the text. His case against building dams in Marble Gorge and within the Grand Canyon is well documented and seemingly sound. He and David Brower, editor of the book, assert that the dam at Glen Canyon was not needed. I am afraid it will take more than these statements to convince everyone that the Sierra Club is 100 per cent right and the U.S. Bureau of Reclamation 100 per cent wrong.

However, no matter how one looks at *Standing Up Country* and *Time and the River Flowing*, they are beautiful books full of informative reading.

WILLARD LUCE
*Author and Naturalist*

The editors of NATURAL HISTORY regret that the millipede, a diplopod, was erroneously called an insect in the subtitle of T. and H. E. Eisner's article, "Mystery of a Millipede," which appeared in the March, 1965, issue.

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# Sabino Grove

## Students make flora and fauna survey of an

By Eric Leshan, Nelson Samuels,

Wishing to conduct original investigations in little-studied areas, our ecology study groups from Pacific High School, a small private school in Palo Alto, California, have made three separate trips into Sonora, Mexico. Our first visit was in February, 1963. As we drove south from the Mexican border to Guaymas, on the Gulf of California, we were surrounded by arid conditions. Traveling inland from Guaymas, we left the creosote bush *(Larrea)* desert near the coast, passed through the mesquite grasslands of the plains, and gradually rose into a broad belt of thorn forest. Finally, in a remote, sparsely populated area, we entered the short tree forest in the foothills of the Sierra Madre. Although the changes we observed occurred principally because of the increase in rainfall with the rise in elevation, it was apparent that all of these communities were still adapted to arid or semiarid conditions.

This region of Mexico is situated midway between the Temperate Zone and the tropics. Arid deserts lie to the north, and moister jungle vegetation lies to the south. The short tree forest, at an elevation ranging from 1,000 to 3,000 feet, is subject to mild winter rains typical of the Temperate Zone (roughly five inches annually) and the violent summer storms typical of the tropics (fifteen inches annually). These brief rainy seasons are separated by prolonged periods of drought.

Our study group first entered this stunted forest during the spring dry season when most of the trees were bare. Their leaves had been shed as an adaptation to conserve moisture. There was little green to be seen except for cacti and the chlorophyll-bearing bark of some of the trees, especially

# Ecology Study

## unusual site in the Sierra Madre foothills

Bruce Hobson, and Charles Coughlan

species of *Bursera.* In the midst of this desolate, gray maze of dead-looking sticks, we came upon a remarkable "ecological island." We entered the valley of a small tributary of the Rio Cedros and saw before us a towering stand of giant conifers that we soon discovered to be Montezuma bald cypress *(Taxodium mucronatum),* called "sabinos" by the Mexicans. The dense grove extended for about 2,000 feet along the arroyo and was 100 to 150 feet wide. Fed by natural springs that kept the ground moist the year round, the grove provided a sheltered oasis for plants and animals poorly adapted to the surrounding, arid short tree forest. Within the grove were organisms typical of the shaded, humid understories of tropical jungles to the south, as well as others typical of dense forests to the north. We determined to study the environmental influences on these plants and animals, and to do so made two additional trips to the grove —in April, 1964, during another spring dry season and in September, 1964, during the late summer rainy season.

To study the plant life of the area, we (1) made a survey of the vegetative pattern inside the sabino grove and in the short tree forest immediately surrounding it, and (2) made a transect across a representative portion of the grove in which we plotted the positions, sizes, leaf areas, and growing conditions of the plants.

Sabinos occur only in a few, small pockets in canyons and arroyos of the Sonoran short tree forest but are much more prevalent in the moister states to the south. In the past, the trees have been heavily timbered for use as lumber, in cabinetmaking, and for coffins, but today they are protected by Mexico's Department of Forestry.

**Nelson Samuels**, one of the authors, climbs a *tepeguaje* tree for mistletoe.

During both the rainy and dry seasons there are four levels of foliage within the sabino grove *(see diagrams on page 18)*. In the short tree forest outside the grove, however, there are only three rather poorly defined levels, and these are reduced to two during the dry season when the ephemeral herbs of the first level wither and vanish. The uppermost level in the short tree forest consists of a wide variety of stunted trees that range in height from 20 to 35 feet. By contrast, the uppermost level within the grove is formed by the sabinos, which grow up to 130 feet tall and 7 feet in diameter and closely resemble the coast redwoods *(Sequoia sempervirens)* of California. Indigenous giant figs, or *chunas (Ficus padifolia)*, grow along the grove's western perimeter.

The seasonal transformation of the short tree forest is dramatic. Within days after the first rain, the parched, leafless landscape turns into a lush, green tangle. The island vegetation, however, remains green and does not change greatly with the rainy and dry seasons. This is caused both by the regulating effect of the year-round water supply from the springs and the perennial shelter provided by the sabinos and figs.

The sabinos of our study grove, as well as those of another grove several miles away, showed no marked sign of dropping needles at any season. This is of note because two references on Mexican plant life—Walter Pesman's *Meet Flora Mexicana* and Howard Scott Gentry's *Rio Mayo Plants*—state that the sabino is deciduous or partly deciduous during the spring dry season. The groves we surveyed were abundantly supplied by spring water, however, and perhaps the shedding of needles as reported elsewhere may be triggered by water scarcity. Gentry also states that the giant fig is sometimes deciduous during the dry season. Here again, however, we saw no active sign of defoliation in our area. But in September we saw hordes of caterpillars busily attacking many of the fig trees and stripping them bare, and this could possibly account for Gentry's observation. Local villagers assured us that the trees would not be killed, but would sprout new leaves the next rainy season.

The leaf areas of the lower foliage levels are conspicuously larger than those of the upper levels (2.5 sq. cm. to 150 sq. cm. for leaves of first level plants within the grove, as opposed to 0.2 to 48 sq. cm. for those of the fourth level). Large leaf-surface areas allow for adequate photosynthesis despite a shaded environment, which can be tolerated in the more protected parts of the grove where increased humidity and decreased temperature and air movement reduce the rate of transpiration. In the spring the temperature is often 5 to 10 degrees cooler inside the grove than outside. Even in the dry season the humidity inside the grove

**Bruce Hobson** leaves the campsite to take notes on the plant life of the grove.

may reach saturation point, as evidenced by the mist that sometimes shrouds the trees in the early morning. No mist forms outside the grove.

The lower foliage levels vary with changes in soil and light conditions. Small plants are virtually absent in areas where summer floods have washed away the surface soil and have left a tangle of roots and cypress knees. In our transect the plants with the largest, most delicate leaves grow in the most shaded and wind-protected spot —beneath the sabinos at the base of a low cliff on the west side of the grove. Here a dark-green Arum lily may be found, along with a variety of other broad-leaved jungle vines and herbs. The dominant ground-level plant of the cliff face is an herb with large, deeply indented leaves. Called *barboria* by the villagers, this small herb *(Dorstenia drakeana)* belongs to the same family (Moraceae) as the giant figs that grow nearby. It has a disk-shaped fruit that resembles, on its surface, the inside of a fig. The *barboria*'s swollen corm stores water and food, thus permitting its survival under conditions of rapid drainage. This plant is even able to grow in the crevices of sabino trunks. Its corms are ground into a paste and used by the villagers to treat infections. Another plant, the kapok tree, or *pochote (Ceiba acuminata)*, has similarly adapted to the cliff environment by having a large tuberous rootstock for storing water.

In addition to providing shade and protection to understory plants, the sabinos provide support for a number of epiphytic plants. Mosses, lichens, and a species of bromeliad *(Tillandsia recurvata)* adorn the lower outer branches. These bromeliads, belonging to the pineapple family, are characteristic epiphytes of tropical forests to the south. One curious epiphyte, a small species of cactus, grows in the crevices of the sabino and fig trunks.

ANOTHER plant that grows on the sabinos—although infrequently—is a strangler fig *(Ficus cotinifolia)*. This tree seeds in the crotches or crevices of other trees and sends roots to the ground. These eventually choke out the host tree (NATURAL HISTORY, November, 1964). We found strangler figs in the central portion of the arroyo, near the stream. Their strange seeding habit may be an adaptation to the violent flash floods that rage through the arroyos in summer, doubtlessly destroying many seedlings not out of reach of the water. The fig fruits are relished by the village children, as well as by the birds.

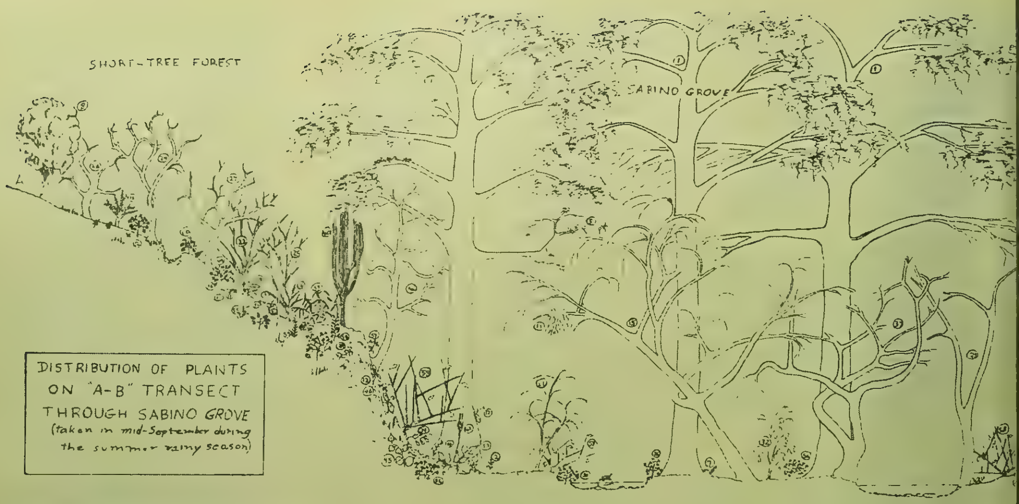
In considering the ecology of the area, it would be a mistake to ignore the relationship between the villagers, their domestic animals, and the grove. The village of Estrella, situated just outside the grove, was originally settled by the Mayo Indians, a tribe for which the Rio Mayo was named. The village is as dependent upon the perennial source of water as are many of the creatures of the grove and the sabinos themselves. Cattle are driven daily to the grove to drink, and pigs, chickens, and goats wander there constantly. The presence of dogs may account for the fact that we saw no other predatory animals. The people live close to the land and depend on the local flora for foods, building materials, medicines, and spices. Even children know the names and uses for more than a hundred plants.

The villagers took great interest in our expedition, and small boys helped us collect turtles, frogs, and insects. One young man, Roberto Valenzuela, patiently helped us record the local names and uses of the plants on our transect *(see chart, page 19)*. The sap of one dominant plant within the grove, a large, spreading bush called *batayaqui (Montanoa Rosei)*, yields a poison formerly used on arrow tips. Its straight branches are now utilized in construction. The grotesque, tubular fruit of another plant, the wiry shrub *papache (Randia echinocarpa)*, is highly nourishing and is eaten by the villagers, as well as by the parrots

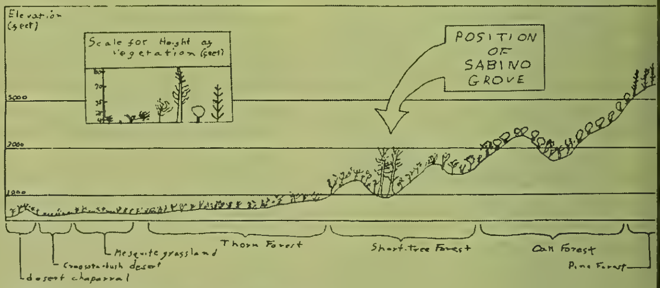
**CATERPILLARS** congregate in a black mat on the trunk of a giant fig tree.

**MEXICAN garter snake (*Thamnophis* sp.) coils in a branch of *papache*.**

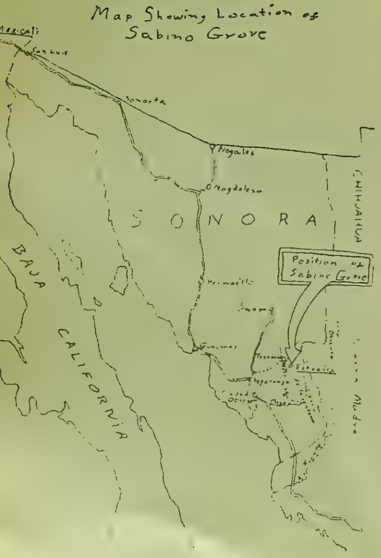
**BLACK WITCH MOTH (*Erebus odorata*) is well camouflaged by a sabino root.**


SHORT-TREE FOREST
SABINO GROVE
DISTRIBUTION OF PLANTS ON "A-B" TRANSECT THROUGH SABINO GROVE
(taken in mid-September during the summer rainy season)

**Plants** that were found to grow along transect, which was plotted through a representative portion of the sabino grove and the short tree forest, are numbered to match the chart at right.


Elevation (feet)
Scale for Height of vegetation (feet)
5000
3000
1000
POSITION OF SABINO GROVE
Thorn Forest
Short-tree Forest
Oak Forest
Pine Forest
Mesquite grassland
Creosote-bush desert
desert chaparral

**Elevation** of the grove, situated in the short tree forest, is about 1,000 feet. Sabinos grow to 130 feet tall and 7 feet in diameter. They closely resemble California's coast redwoods.

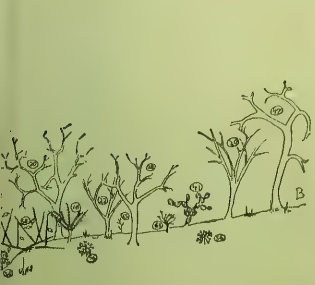

Map Showing Location of Sabino Grove
Mexicali
San Luis
Sonorta
Nogales
Magdalena
SONORA
CHIHUAHUA
Position of Sabino Grove
Hermosillo
Guaymas
Esperanza
BAJA CALIFORNIA
Sierra Madre

**Called** an "ecological island" by the students, the lush, spring-fed grove is surrounded by semiarid conditions. Towering sabinos are usually found in moister tropical states to the south.

**Location** of the sabino grove, which was chosen for field study by Pacific High School biology students, is in the Sonoran foothills of the Sierra Madre, inland from Guaymas, Mexico.

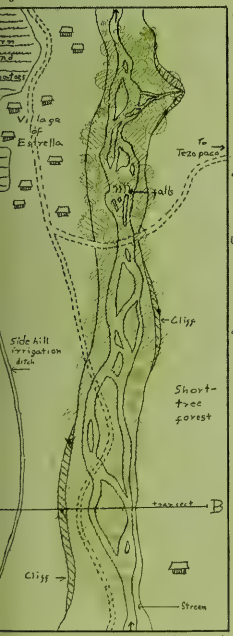
Drawings by
Charles Coughlan

SHORT–TREE FOREST

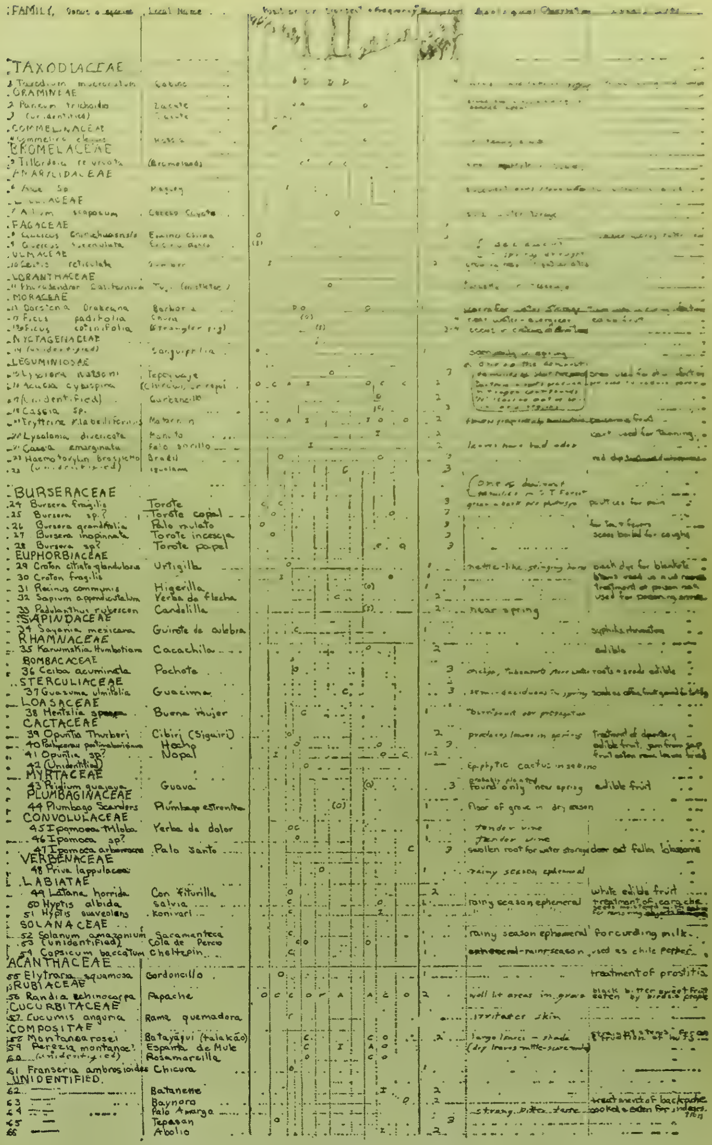


**VEGETATION** details in chart include the plants' scientific and local names (and uses), their transect positions and frequency, and their foliage level. Note students' ecological observations.

agram of Sabino Grove


Code for Major Trees within Sabino Grove
"Sabino" (Taxodium mucronatum)
"Chuna" or giant fig (Ficus padifolia)
"Guacima" (Guazuma Ulmifolia)
"Iguelama" Family leguminosae
"Pochote" or kapok tree (Ceiba acuminata)
"Tepeguaje" (Lysoloma Watsoni)
"Guayaba" or guava (Psidium guajava)
Village of Estrella
To Tezopaco
Falls
Cliff
Side hill irrigation ditch
Short-tree forest
transect
B
Cliff
Stream

ne A-B indicates position of study transect



| FAMILY, Genus & species | Local Name | Foliage level | Ecological Observations | Uses |
|---|---|---|---|---|
| TAXODIACEAE | | | | |
| 1 Taxodium mucronatum | Sabino | | [illegible] | |
| GRAMINEAE | | | | |
| 2 Panicum trichoides | Zacate | | [illegible] | |
| 3 (unidentified) | Zacate | | | |
| COMMELINACEAE | | | | |
| 4 Commelina elegans | [illegible] | | [illegible] | |
| BROMELIACEAE | | | | |
| 5 Tillandsia recurvata | (Bromeliads) | | [illegible] | |
| AMARYLLIDACEAE | | | | |
| 6 Agave sp | Maguey | | [illegible] | |
| LILIACEAE | | | | |
| 7 Allium scaposum | Cebollo Coyote | | [illegible] | |
| FAGACEAE | | | | |
| 8 Quercus chihuahuensis | Encino Chino | | [illegible] | [illegible] |
| 9 Quercus tuberculata | [illegible] | | [illegible] | |
| ULMACEAE | | | | |
| 10 Celtis reticulata | [illegible] | 2 | [illegible] | |
| LORANTHACEAE | | | | |
| 11 Phoradendron californicum | [illegible] (mistletoe) | | [illegible] | |
| MORACEAE | | | | |
| 12 Dorstenia drakeana | Barbona | | [illegible] water storage | [illegible] |
| 13 Ficus padifolia | Chuna | | [illegible] evergreen | edible fruit |
| 13a Ficus cotinifolia | (Strangler fig) | 3-4 | [illegible] | |
| NYCTAGINACEAE | | | | |
| 14 (unidentified) | Sanguinaria | 1 | seen [illegible] in spring | |
| LEGUMINOSAE | | | | |
| 15 Lysiloma watsoni | Tepeguaje | 3 | one of the dominant [illegible] | [illegible] |
| 16 Acacia cymbispina | (Chirowi, or [illegible]) | 2 | [illegible] | [illegible] |
| 17 (unidentified) | Garbancillo | 2 | [illegible] | |
| 18 Cassia sp. | | 3 | | |
| 19 Erythrina flabelliformis | Mabarin | 2 | flowers [illegible] | [illegible] food |
| 20 Lysiloma divaricata | Mauto | 2 | | bark used for tanning |
| 21 Cassia emarginata | Palo zorrillo | 2 | leaves have bad odor | |
| 22 Haematoxylon brasiletto | Brasil | 3 | | red dye [illegible] |
| 23 (unidentified) | Iguelama | 3 | | |
| BURSERACEAE | | | (One of dominant [illegible] in S T Forest) | |
| 24 Bursera fragilis | Torote | 3 | green [illegible] bark [illegible] photosyn[illegible] | poultices for pain |
| 25 Bursera sp.? | Torote copal | 3 | | |
| 26 Bursera grandifolia | Palo mulato | 3 | | for [illegible] fevers |
| 27 Bursera inopinnata | Torote incescia | 3 | | seeds boiled for coughs |
| 28 Bursera sp? | Torote papel | 3 | | |
| EUPHORBIACEAE | | | | |
| 29 Croton ciliato-glandulosa | Urtigilla | 1 | nettle-like stinging hairs | [illegible] dye for blankets |
| 30 Croton fragilis | | 1 | | [illegible] |
| 31 Ricinus communis | Higerilla | 1 | | treatment of poison [illegible] |
| 32 Sapium appendiculatum | Yerba de flecha | 2 | | used for poisoning arrows |
| 33 Pedilanthus rubescens | Candelilla | 2 | near spring | |
| SAPINDACEAE | | | | |
| 34 Sayenia mexicana | Guirote de culebra | 1 | | syphilis treatment |
| RHAMNACEAE | | | | |
| 35 Karwinskia Humboltiana | Cacachila | 2 | | edible |
| BOMBACACEAE | | | | |
| 36 Ceiba acuminata | Pochote | 3 | [illegible], tubercles store water | roots & seeds edible |
| STERCULIACEAE | | | | |
| 37 Guazuma ulmifolia | Guacima | 3 | semi-deciduous in spring | [illegible] as coffee, fruit good for cattle |
| LOASACEAE | | | | |
| 38 Mentzelia ~~[illegible]~~ | Buena mujer | 1 | "Burr" fruit aid propagation | |
| CACTACEAE | | | | |
| 39 Opuntia Thurberi | Cibiri (Siguiri) | 2 | produces leaves in spring | Treatment of dysentery |
| 40 Pachycereus pectinaboriginum | Hecho | 3 | | edible fruit, gum from sap |
| 41 Opuntia sp? | Nopal | 1-2 | | fruit eaten new leaves fried |
| 42 (Unidentified) | | — | Epiphytic cactus in sabino | |
| MYRTACEAE | | | | |
| 43 Psidium guajava | Guava | 3 | probably planted<br>found only near spring | edible fruit |
| PLUMBAGINACEAE | | | | |
| 44 Plumbago Scandens | Plumbago estrenita | 1 | floor of grove in dry season | |
| CONVOLVULACEAE | | | | |
| 45 Ipomoea triloba | Yerba de dolor | 1 | tender vine | |
| 46 Ipomoea sp? | | 1 | tender vine | |
| 47 Ipomoea arborescens | Palo Santo | 3 | swollen root for water storage | deer eat fallen blossoms |
| VERBENACEAE | | | | |
| 48 Priva lappulacea | | 1 | rainy season ephemeral | |
| LABIATAE | | | | |
| 49 Lantana horrida | Con fiturilla | 2 | | white edible fruit |
| 50 Hyptis albida | salvia | 1 | rainy season ephemeral | treatment of earache |
| 51 Hyptis suaveolens | Konivari | 1 | | seeds [illegible] for [illegible] |
| SOLANACEAE | | | | |
| 52 Solanum amazonium | Sacamanteca | 1 | rainy season ephemeral | for curdling milk |
| 53 (unidentified) | Cola de Perro | 1 | | |
| 54 Capsicum baccatum | Cheltepin | 1 | ~~ephemeral~~-rainy season | used as chile pepper |
| ACANTHACEAE | | | | |
| 55 Elytraria squamosa | Gordoncillo | 1 | | treatment of prostitis |
| RUBIACEAE | | | | |
| 56 Randia echinocarpa | Papache | 2 | well lit areas in grove | black bitter sweet fruit eaten by birds & people |
| CUCURBITACEAE | | | | |
| 57 Cucumis anguria | Rama quemadora | | irritates skin | |
| COMPOSITAE | | | | |
| 58 Montanoa rosei | Batayaqui (talakão) | 2 | large leaves — shade (dry leaves [illegible]) | [illegible] |
| 59 Perezia montanae? | Espanta de Mule | | | |
| 60 (unidentified) | Rosamarcilla | | | |
| 61 Franseria ambrosioides | Chicura | 1 | | |
| UNIDENTIFIED. | | | | |
| 62 | Batanene | 2 | | |
| 63 | Baynora | 2 | | treatment of backache |
| 64 | Palo Amarga | | strong bitter taste | cooked & eaten for [illegible] |
| 65 | Tepasan | 3 | | |
| 66 | Abolio | 2 | | |

PLANTS OBSERVED IN THE SABINO GROVE AND ADJACENT SHORT-TREE FOREST

Consecutive numbering corresponds to numbering on transect

Code for Frequency

( ) indicate plants not found on transect but occuring elsewhere in grove

I= infrequent
O= occasional
C= common
A= abundant
D= dominant

and macaws that frequent the grove. The woody fruit of *guasima (Guazuma ulmifolia)* is ground to make tortillas, and its seeds sometimes serve as a coffee substitute.

Herbs that spring up near the edge of the sabino grove during the rainy season have many uses. Leaves of a mint called *salvia (Hyptis albida)* are made into poultices for earache, and seeds of a near relative, *konivari (Hyptis suaveolens)*, can be moistened with saliva and used to remove foreign objects from the eyes. *Sacamanteca (Solanum amazonium)*, of the nightshade family, gets its local name from its use in curdling milk for cheese. *(Saca-manteca* means "draw out the fat.") The small, round fruit of *chiltepin (Capsicum baccatum)*, also of the nightshade family, serves as a substitute for chili pepper.

A twining cactus known as *siquiri (Opuntia* sp.*)*, which grows on the margin of the sabino grove, is of interest not only because its fruit is said to be an effective combatant of dysentery, but because new shoots that grow during the rainy season produce small, fleshy leaves instead of the usual spines. These leaves provide additional green surface area for photosynthesis during the periods when there is plenty of water and when the cactus is shaded by the sudden leafing of plants growing above it. During the dry season, however, when the plant is exposed to direct sunlight, its leaves are shed and are replaced by typical cactus spines (actually modified leaves). With its surface area effectively reduced to conserve moisture, the *siquiri* carries on photosynthesis only in its fleshy green stem, as do other cacti.

As elsewhere, the land fauna within the sabino grove is to a large degree dependent on the vegetation of the area for food and shelter and, in turn, may have a direct impact on the vegetation. For example, when caterpillars (family Arctiidae) devour the leaves of the giant fig so extensively that sunlight floods down through the gaps created in the grove's canopy, large-leaved plants characteristic of the shaded ground story are often replaced by smaller-leaved leguminous plants more adapted to sunlight.

In spite of the many insect-eating birds of the area, we saw no evidence of predation on the caterpillars. This may be because of the mildly stinging hairs that cover their bodies. When the caterpillars are not actively feeding, they congregate on the fig trunks in furry, black mats up to two feet across. (This tendency to congregate in large numbers, characteristic of many organisms with deterrent features such as stinging organs or bad taste, discourages predators from attacking more than one of a group.)

Continuing the food chain, we saw tiny ants gather the bright-green caterpillar droppings and transport them underground. We did not see the ants collect any other food, and possibly they use the droppings to grow a culture of edible fungi, as do their leaf-cutting cousins. True, these ants lack the powerful clipping jaws of the leaf-cutter ants, but, after all, their leaf supply is already cut and bundled by the caterpillars. The ants were fed upon by larval ant lions, which, in their adult form, in turn become prey for insect-feeding birds and bats.

The most strikingly colored insects in the grove were the dragonflies. One *(Libellula* sp.*)* was brilliant lavender, while another *(L. croceipennis)* was a velvet red that glowed like a flare when the insect was in the sunlight. In the deep shade of the grove, however, these bright dragonflies blend into the shadows remarkably well. In the surrounding short tree forest, where such heavy shadows are lacking, the species of dragonflies we saw were generally duller and paler. When they came to rest they were difficult to spot, even in bright sunlight. (We observed a similar phenomenon in the coloration of the birds of the area; those in the short tree forest were generally duller.)

Even within the heavy shade of the sabino grove, brilliant coloration is largely restricted to those insects that are capable of quick flight, or that have stinging organs or some other effective protection. The black witch moth *(Erebus odorata)* is a striking example of protective coloration. Dark but richly colored, this large moth rests by day with its wings outstretched against the dark sabino roots and is nearly invisible. A pale-green species of spider that builds its web in a light-green, nettle-like plant that the villagers call *uruquenia (Croton ciliatoglandulosus)* was so well camouflaged that we discovered it only after we had photographed the plant and developed the picture.

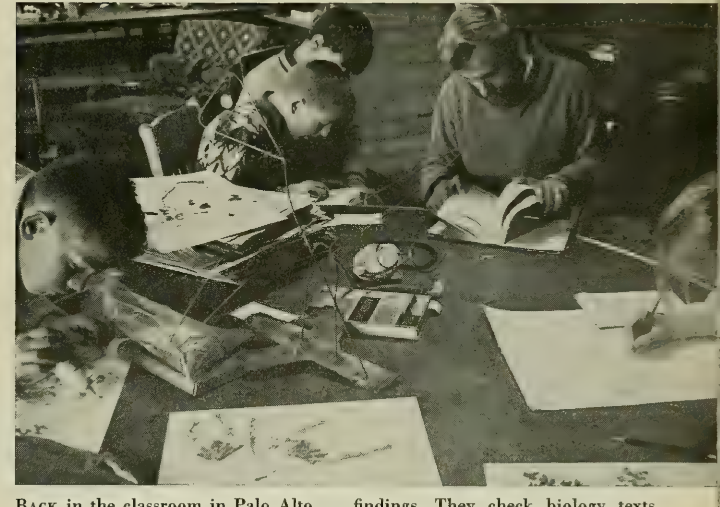
The "horse grasshopper" *(Taeniopoda eques)* presented one of the most interesting examples of protective coloration. On two occasions we found this grasshopper in the boat-thorn acacia, or *chirowi (Acacia cymbispina)*, one of the common plants outside the grove. The grasshopper's forewings are mottled with olive green and greatly resemble the pinnate leaves of the acacia. Its underwings

**Villagers** from nearby Estrella help students identify plants and record their local names and uses. Mexican children helped to collect specimens.

**Domestic animals**, such as goats right, play a role in grove's ecolog

are bright maroon, just like the thorns of the acacia. Many species of insects, especially moths, have colorful underwings that are used to attract mates, and that can be concealed by dull-colored forewings when the insects are at rest, but the underwings of the horse grasshopper have an additional function, as we found out. When pursued, the insect spreads its wings and half flies, half leaps from one acacia twig to another. The sudden flashing of its thorn-colored underwings may be a strong deterrent to any bird or other creature familiar with the bristling, boat-thorn acacia.

Two toad species within the grove also were good examples of protective coloration. The red-spotted canyon toad *(Bufo punctatus)* blended in well on the moist, litter-flecked forest floor. The larger *Bufo mazatlanensis*, a species typical of more southern, coastal regions of Mexico, preferred



**Back** in the classroom in Palo Alto, students and teacher organize their findings. They check biology texts to explain their field observations.

the northern portion of the grove, where it blended into the pitted, yellowish-gray volcanic rocks.

BIRDS we observed within the sabino grove can be grouped as follows: (1) residents of the short tree forest that enter the grove for water or food or to nest; (2) birds that are typical of temperate forested regions to the north (the United States and southern Canada) that have migrated or strayed south; and (3) birds typical of the moister jungle regions to the south (states of Sinaloa and Nayarit) that have wandered north.

The bird population in the grove proved largest during the dry season when climatic differences between the short tree forest and the sabino grove are the greatest. First, during the dry season birds of the short tree forest (Group 1) are attracted to the grove for water. Second, the birds adapted to more heavily forested regions (Groups 2 and 3) are reluctant to venture out into the short tree forest when it is parched and leafless.

We noticed that a number of the birds of Group 2 (summer tanager) and Group 3 (San Blas jay, military macaw, red-crowned parrot) were vividly colored in reds, blues, and/or bright greens. The birds of Group 1 (ground dove, elegant quail, and Gila woodpecker) were generally more drab, with more yellows, tans, and grays. This indicates that the selective advantages of brilliant coloration tend to exceed the disadvantages in a heavily forested community, while in open, arid country the reverse is true. Brilliant coloration is often a positive factor in the selection of mates; also, vividly colored males can be useful in luring predators away from the nest. However, unless the bird lives in a habitat where it can hide easily and its colors can be muted in shadows, vivid coloration would place it in peril.

The bird species we observed occupied a wide variety of ecological niches. There were seed eaters, fruit eaters, nectar feeders, insect eaters, nocturnal and diurnal predators, scavengers, and carrion feeders. The fruit eaters were usually birds that had strayed up from the tropics (Group 3), while the insect eaters were largely migrants or strays from the north (Group 2). The insect-eating birds were generally observed in trees other than the sabinos, especially in the giant figs. This may be because the tissues of the sabinos, like those of their close relatives, the coast redwoods, contain high quantities of tannin that discourage insects (and consequently insect-eating birds).

The year-round water supply within the sabino grove supports a large aquatic community that could not possibly survive in arroyos of the short tree forest where the water supply is intermittent. For the most part this community does not differ greatly from pool and stream communities in other parts of North America, and need not be described in detail. One of the stream's inhabitants, however, does deserve special attention. The turtle *Kinosternon integrum* occurred in surprising abundance, for we saw one or more in almost every pool, large or small, throughout the grove. This animal is carnivorous, grows up to five or six inches long, and looks like a cross between a snapping turtle and a box turtle. It has a long neck and a large head with very powerful jaws, while on its underside there are two hinged plates that enable it to retract completely inside its shell. The turtle's nostrils are snorkel-like, so that it can breath in shallow water while standing on tiptoe on the bottom with its neck extended.

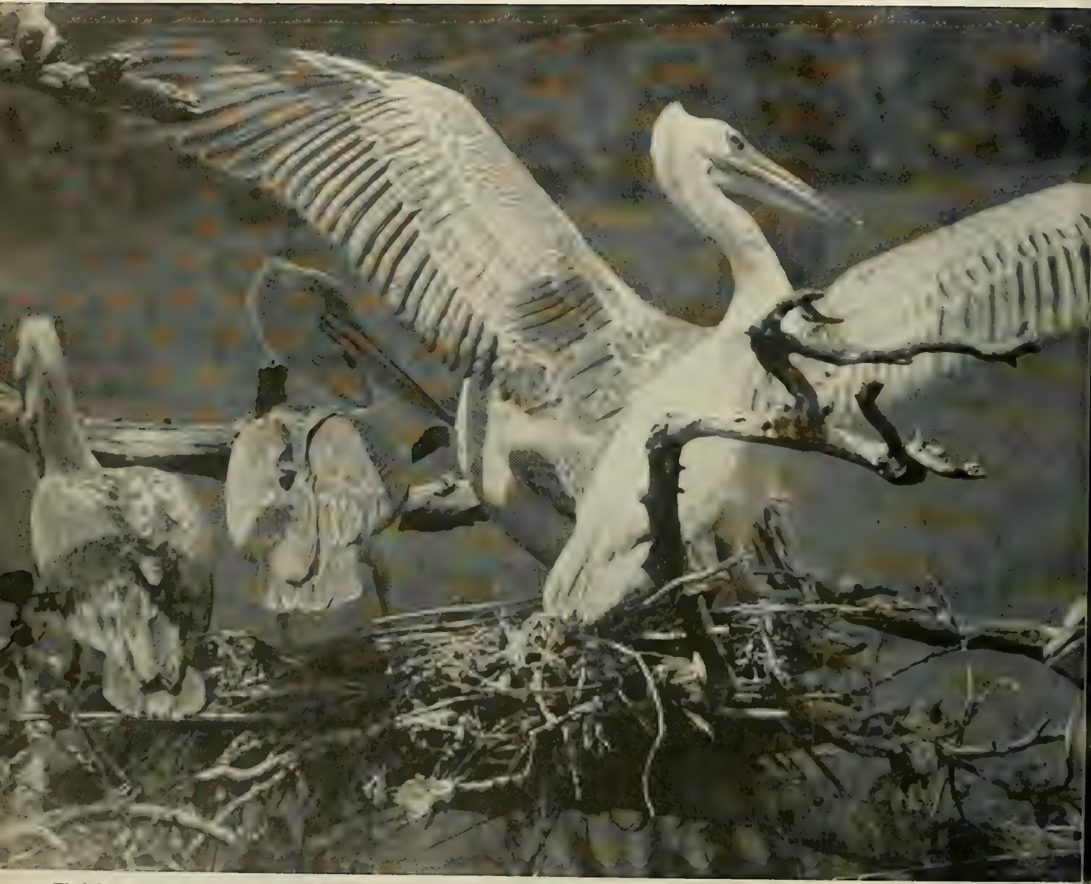
This turtle is a partner in a good example of plant-animal commensalism. Its upper shell is covered with a luxurious growth of algae that, on the one hand, camouflages the animal among the algae-covered rocks in the stream; the shell, on the other hand, provides good anchorage for the algae. Because the turtle seeks out and basks in small patches of sunlight, the algae growing on its back receive proportionately more sunlight than the algae growing on the rocks. Sunlight is, of course, necessary for the algae's photosynthetic processes. In addition, when flash floods beat on the algae-covered rocks or bury them in silt, the turtles scurry for shelter in caves beneath the sabino roots. The algae on the turtle's back are also well protected during the dry season, when the turtles follow the receding water.

WE have found that during the three trips we made to the sabino grove we did little more than scratch the surface in our attempts to learn about the ecology of the area. When a field trip is over, much of the work and much of the learning in connection with the trip are still ahead of us. Two intensive weeks in the field are followed by two intensive months in class and laboratory when we are back at school. Our entire high school biology program is orientated around field studies in ecology. Starting with our own observations, and trying to draw together cohesive studies of the areas we investigate, we can confront the different aspects of biology at the point where they converge—in the outdoor community of living things.

MEXICAN boys try to catch moths that have lighted on exposed sabino roots.

TRANSECT crossed this stream, *rig* toward the southern end of the gro

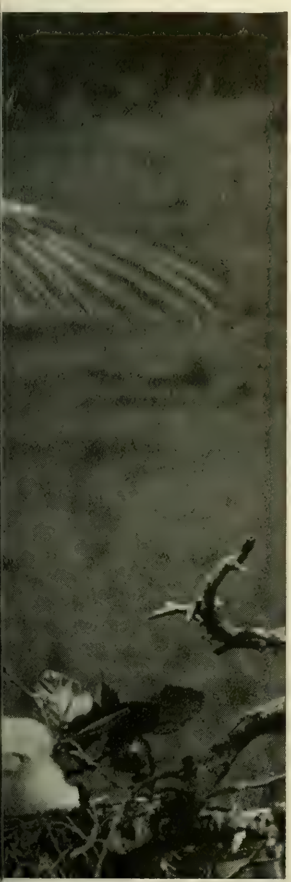
# African



Fledgling tries its wings in nest before first flight. Chick at right is about 10 days old; the others are fully grown.

Pink-backs, at rear and second from the front, accompany this flotilla of Rosy pelicans on Lake Naivasha, in Kenya.

# Pink-backed Pelican



## Legend surrounds this and related species

By James Hancock

The eight species of pelican in the family Pelecanidae are in the order Pelecaniformes, which consists of six families. In this ancient order, which is known from the Oligocene Epoch of some 40 million years ago, are included, in addition to the pelicans, the cormorants, anhingas, boobies and gannets, tropic-birds, and frigate-birds. These Pelecaniformes are the only birds with all four toes connected by webs, the hind toe being turned forward to connect with the inner front toe.

Of the six Old World species of pelican, two—the Rosy, or Old World White, pelican and the Pink-backed—breed in Africa. The Rosy (*Pelecanus onocrotalus*) is also widespread throughout southeast Europe and Asia. Its distribution, however, is discontinuous, and Voous (*Atlas of European Birds*) considers this to be evidence that the species is in the process of dying out. In some areas extensive persecution and disturbance of nesting sites by man is the main cause.

All Rosy pelicans that nest in Europe are migratory, wintering in Africa south of the Sahara as well as on the Persian Gulf and the Red Sea coasts. Some of the birds that breed in Africa may be locally sedentary, provided that food supplies remain abundant, and this is usually the case on the breeding areas of inland water in east central Africa. All breeding is colonial and, where no disturbance by man has occurred, many of the nest sites have been occupied yearly by succeeding generations. The smaller Pink-backed (*P. rufescens*) is confined to the African continent. It wanders locally as far north as the Red Sea to about latitude 23° N., and in his *Birds of Arabia*, Meinertzhagen reports it as a rare straggler to Jidda and south to Aden, but always on the coast. It breeds in suitable places throughout tropical Africa. Roberts, in *Birds of South Africa*, describes it as uncommon down the east coast and rare in the Cape peninsula.

The Rosy pelican is, except during breeding season, generally white, but it has black primaries and primary coverts. Both males and females take on a pinkish tinge during the breeding period. This bird may reach 70 inches in length and may weigh over 24 pounds, which makes it one of the heaviest flying birds. The bill, pouch, and legs are yellow (the bill is whitish purple at the base). The Pink-backed is a much smaller bird—a maximum of 54 inches in length, or about two-thirds the size of the Rosy. It is gray except for a vinous tinge to its back and rump—a color more apparent during the breeding season. The bill and pouch are yellow, and the legs are yellow or orange. It has a very pro-

Adult guarding young sometimes will point beak upward, stretching pouch so tightly that each vein is visible.

Nests often overlap. Adult, *below*, preens as it guards its chicks, and one at rear still incubates its eggs.

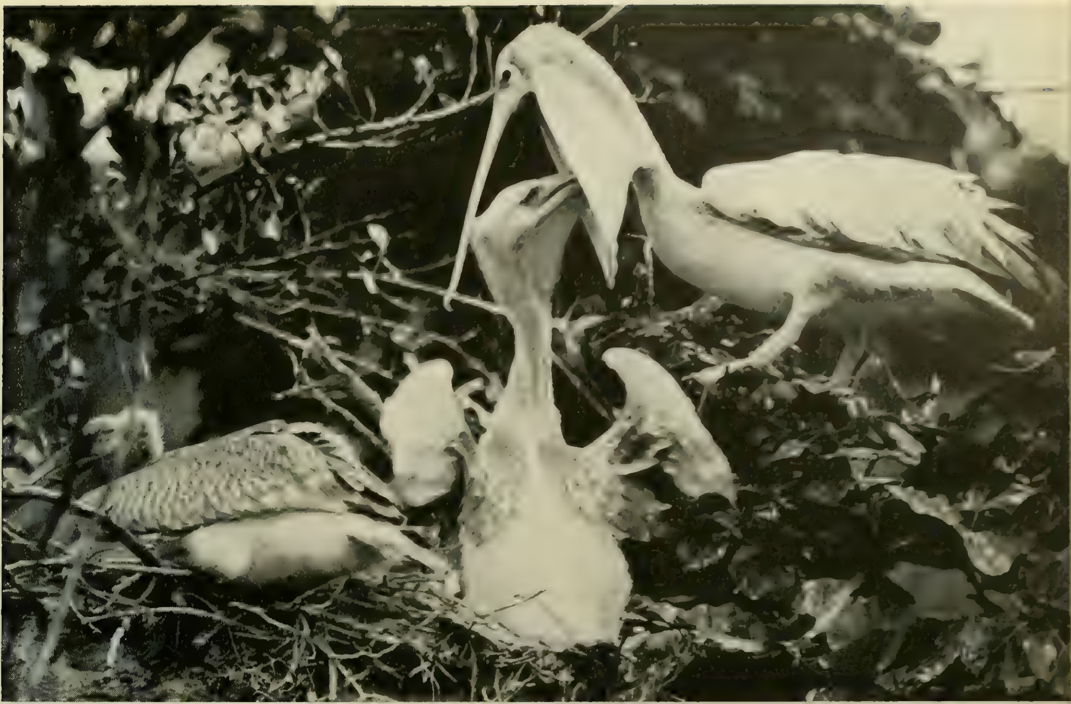
nounced nape crest. The primaries are of a darker gray; they show in flight and easily distinguish the bird from its larger relative, which has such pronounced black wing tips.

Pelicans are generally silent, but during the breeding season, as parents return to their nests, the colony sets up a continual grunting and snarling noise that can be heard from a considerable distance. This noise emanates mainly from the young, but on disgorging food the parents often will reply with a soft groan, the only call they are known to make. The pelican is a long-lived bird; the young mature slowly and seldom breed until they are four years old.

John Williams, who is author of *A Field Guide to the Birds of East and Central Africa*, and who may know more about that area than any other ornithologist, tells me that there are four nesting colonies there, although the birds nest spasmodically in different areas, depending on the food supply. Peter Hill, who took some of the pictures on these pages while District Commissioner at Kinui, Kenya, visited the colony on the flooded Kano Flats near Kisumu, some twelve miles from Lake Victoria in Kenya. Approximately fifty pairs breed there, and all the nests are built high in the wild fig trees.

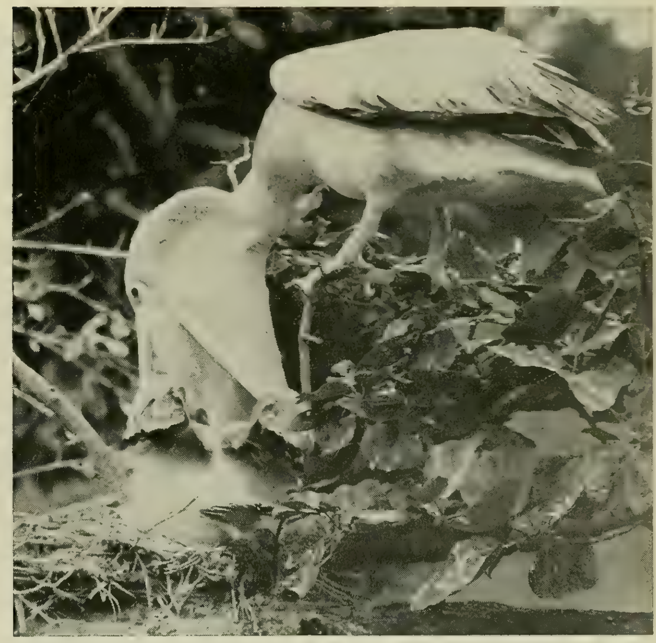
Pelicans ordinarily lay two eggs (greenish blue under the chalk whiteness of the shell) in their absurdly small stick nests. The young, like all members of this altricial group, are born blind and naked, but quickly grow a soft down. As they mature, the plumage of the wings, back, and rump becomes brown; the head and neck are grayish white; the underparts, rump, and back are white. Both adults are kept fully occupied feeding their rapidly growing offspring. The amount of fish consumed is formidable. It is estimated that 150 pounds of fish are needed to raise a young bird from birth to when it leaves the nest in about two months. Thus a constant supply of fish is a prerequisite of a successful breeding colony; abundance of food dictates the breeding season, which consequently varies from year to year as it does with all species of birds breeding on or near the Equator.

During the chicks' first days of total helplessness, the parents dribble half-digested food into their bills, but in a few days the young can sit erect, poke their heads into their parents'



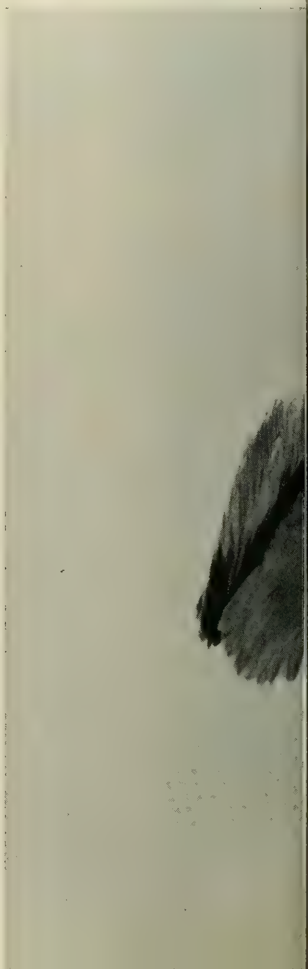
Chick begs food by poking in adult's beak. Parent brings fish in its crop from Lake Victoria, 12 miles away.

Head of young disappears into gullet of adults for the once-daily feeding, which consists of regurgitated fish.



bills, and receive the regurgitated fish straight from the gullet. This process, which is a long and protracted operation, appears to the onlooker to be extremely painful to the adults. Indeed, a medieval legend relates that pelicans puncture their breasts with their bills in order to feed their young on blood. In addition, the pelican is often depicted, "in her piety," as a symbol of Christ's suffering. Some authorities believe the breast-puncturing legend originated from the bird's habit of resting its pouched bill upon its breast, as it appears on the coat of arms of Richard Foxe, Bishop of Winchester, who founded Corpus Christi College, Oxford, in 1516.

On Lake Victoria, as on most of the inland waters of central Africa, the adult pelicans hunt for fish in parties. Sometimes Rosy and Pink-backed swim close together in a "raft," then turn to form a half-circle, and rise with great wing flaps, driving the fish in front of them into shallow water. There the birds scoop them up into their pouches, raising and lowering their bills like handles of a fishing net.



The behavior of the adult arriving at the nest is unlike that of the birds that feed their young immediately. When a pelican returns with food it sits near the nest for a short time before offering its open bill to the young. This may well be a necessity to enable it to regurgitate the fish it brings from some distance away. I noticed this inability to regurgitate at once in both Brown pelicans nesting off Key West in Florida and in their near relatives, the Red-footed boobies of Oahu in the Hawaiian Islands. Birds in a colony of either pelicans or boobies are invariably frightened by the appearance of man or any other predator, and their instinct is to lighten their bodies to enable them to escape more easily. This action does not appear to be possible immediately after feeding, and as much as a minute may elapse before, after much groaning and shaking, the half-digested food is emitted. Unlike the boobies and the Brown pelicans of the New World, pelicans in Africa do not suffer from the predation of frigate-birds, which are found only around Madagascar. Other birds, even the numerous fish eagles, seldom seem to bother them. In Hawaii the introduced mongoose has been observed forcing a young booby to regurgitate food (usually squid) by climbing up into the nest during the absence of the adult. Its mere presence is apparently enough to frighten the chick into disgorging its food, although on this occasion the mongoose became exasperated at the length of time the bird took and seized it by the back of the neck. As soon as the fish was regurgitated, the mongoose promptly released the chick and ate the fish. Although there is no record of this happening in Africa, the likelihood certainly exists.

Parties of pelicans regularly fly together, often in a straight line or in V formation, and the slow, strong wingbeat followed by a glide, each bird in harmony with its fellow, is a characteristic sight. For such a large and powerful bird it is extremely graceful once it is in the air, and it will ride up on thermals, soaring on motionless wings high over the water.

It is ironic that the very symbol chosen by man himself to depict Christ's suffering should have itself suffered such persecution. David likened himself to a pelican in a prayer of the afflicted: "I am like a pelican of the wilderness. . . ." (Psalm 102:6.) Early great writers—Aristotle, in *Historia Animalium*, and Hugo de Folieto, in *Aviarium*—mentioned the pelican, and later Dante and Shakespeare referred to it as a "restorer of life." But then the picture changed. At the turn of this century Dixon Lanier Merritt wrote the famous limerick that begins:

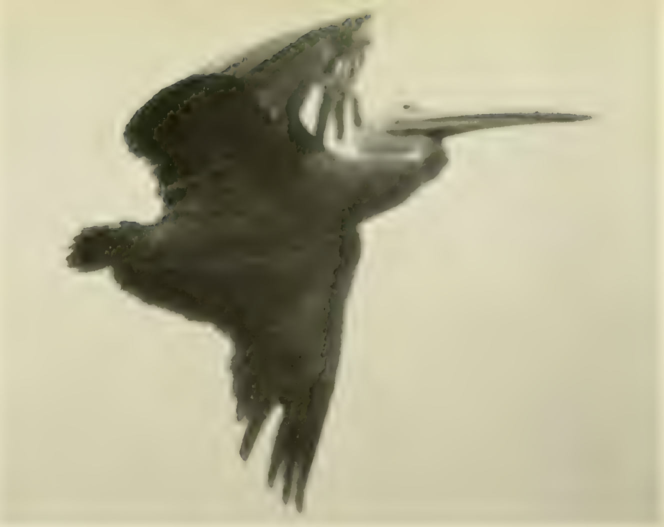
"A wonderful bird is the pelican,
His bill will hold more than
his belican. . . ."

and curiously enough, its popularity was so great that the ancient bird began to be treated with ridicule. At about the same time, several species began to suffer from human persecution, and birds like the pelican cannot possibly survive unless they are left undisturbed to breed. Two species, the Rosy and the Dalmatian, were specially harmed in Europe because of the marsh drainage. Guy Mountfort has reported a tragedy he witnessed in Bulgaria on Lake Sreburna in a wildlife sanctuary, where peasant fisherman burned vast areas of reed beds, and the nests and nestlings of pelicans were wiped out (NATURAL HISTORY, April, 1961). A hundred years ago a million birds nested in that Danube area; now only 700 pairs remain.

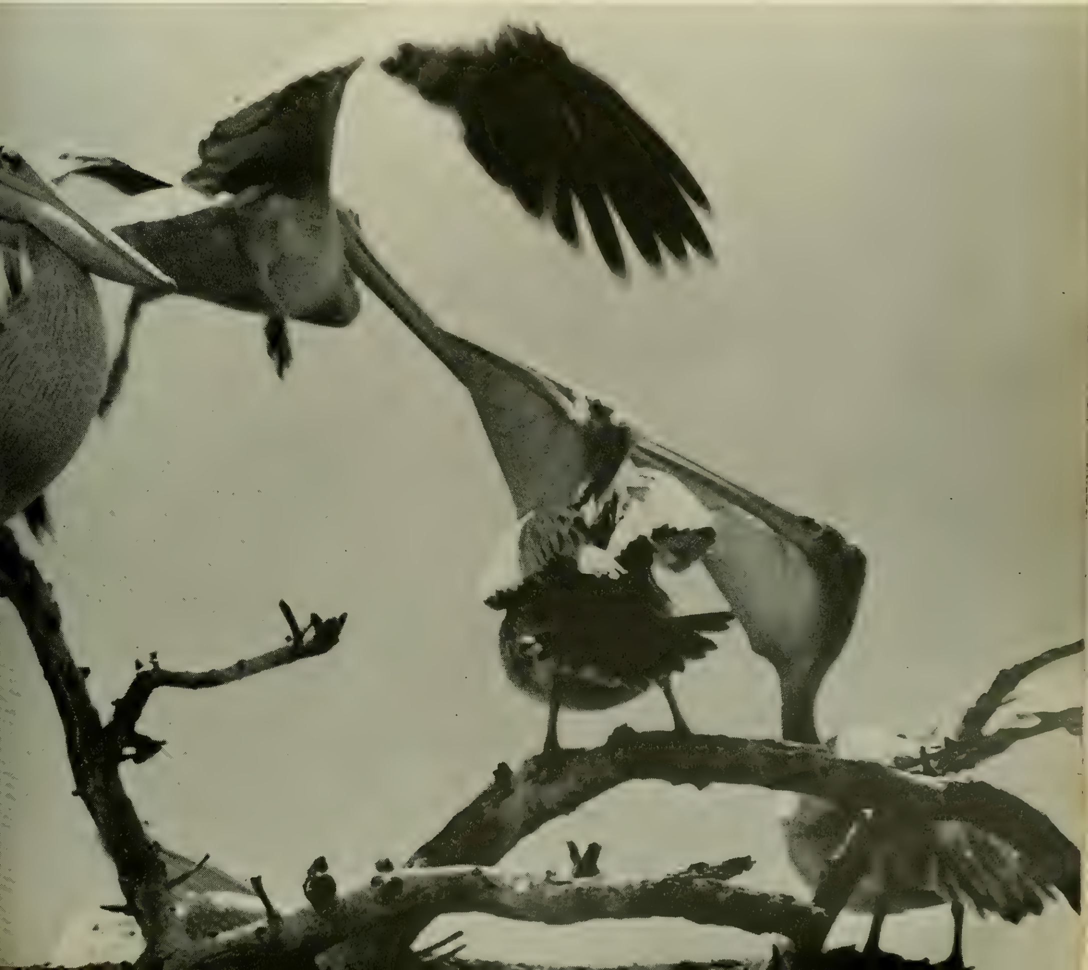
In Africa, the Pink-backed has maintained its numbers, and breeding places have been left undisturbed. Colonies at Sokoto and Kana in northern Nigeria are actually within the walls of the towns, but fortunately the birds have been left to flourish.

at the left has just taken flight. egs are drawn back; when in full t they are tucked in next to body.

Although clumsy at take-off, pelican is remarkably graceful aloft. Flexibility of the wing is noticeable at the right.



Favored perching places are guarded jealously, and the incumbents discourage intruders by snapping with their beaks.



# SKY REPORTER

## Mariner IV may provide us with new knowledge about Mars

By Thomas D. Nicholson

The remarkable picture at the left best illustrates the problem of observing the surface features of the planet Mars. The photograph was taken a few days after the opposition of December 4, 1911. While that was not a favorable opposition (see "Sky Reporter," April, 1965), it was better than average; Mars approached to within 50,000,000 miles of the earth. Nevertheless, in the earth's sky Mars appeared to be no larger than a medium-size lunar crater about twenty miles across. Mars never appears any larger than 1/75 of the apparent size of the moon in our sky, and usually much smaller. Yet from this small image astronomers attempt to determine the nature of the physical features on the planet's surface. It is surprising that we have been able to see as much of Mars as the record to date shows, and it attests to the amazing visual acuity that some of the best telescopic observers have developed and demonstrated.

Aside from the simple geometry of the distance and size of Mars, observation is further complicated by the necessity of looking at it through a turbulent sea of atmosphere. Along our line of sight, and close to the earth's surface, are several hundred miles of atmosphere containing air layers of various temperatures and densities that move and shift both vertically and horizontally. They cause the telescopic image of Mars to blur continually, but the blurring varies from time to time and from place to place on the visible disk of the planet. This is the principal reason why photographs of Mars taken through telescopes have never shown, and really can never be expected to show, as much fine detail of the markings on the surface as can be observed visually through telescopes.

The eye sees the image of Mars with whatever clarity the atmosphere permits. Experienced observers report that the image often clears sharply for brief moments and at irregular intervals. During these periods of "good seeing," they report, the extent and the clarity of observable detail increases dramatically. A trained and patient observer can see several of these moments of clarity during a night, and subsequently can make notes or sketches of what he saw. Putting together these notes and sketches at a later time, he can compose drawings representative of his observations under the most favorable conditions—a technique that has produced the best information we have to date about the surface of Mars. Their reliability and accuracy are shown by the consistency of position, nature, and appearance of markings shown in drawings made over a long span of years by the same and different viewers. Photographs confirm the presence of principal features.

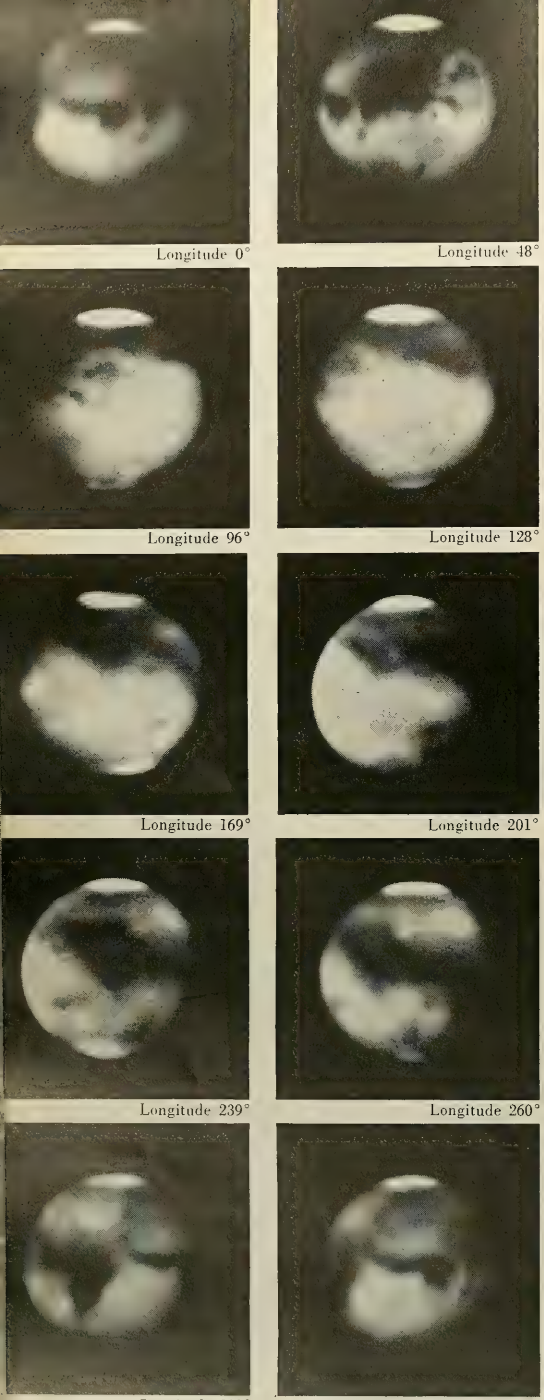
Although photographs have not verified tne many small-scale markings, such as the canals, we cannot jump to the conclusion that they do not exist. Rather, we should keep in mind the inadequacy of our photographic techniques to record the features of such a small object through the earth's atmosphere. Photographic telescopes cannot take advantage of the moments of good seeing that permit the visual observers their best views. As we noted earlier, these moments are unpredictable, and even should a clear moment occur while a photograph is being taken, the camera will integrate all of the light it receives during the time of exposure. The recorded image will show, not the maximum clarity, but the average conditions that occurred during the exposure, even though the exposure is as short as 1/10 second. From all the accounts of experienced observers, the moments of good seeing are so brief that we cannot hope to limit the exposure to such a period, even though we know when one might occur or manage to encounter one accidentally while taking a photograph.

One of the most interesting puzzles that photographic observations of Mars have provided is the appearance of the "blue haze." Beginning about 1903, experiments were made in photographing Mars through suitable filters that would transmit only light of a certain color to the photographic plate. As filters and photographic materials more sensitive to different colors were developed, it became apparent that the surface features of Mars showed up best in photographs taken in a red light, with yellows and blues screened out. The features were less distinct in yellow-light photographs, and were invisible or indistinct on photographs in blue light. On the other hand, yellow and blue photographs showed more clearly the planet's characteristic white polar caps and their changes, and also revealed clouds in polar regions, along the moving edge of the planet, and even at times in the center of the disk.

Most puzzling of all were the blue-light photographs. Even under excellent observing conditions, where red and yellow photographs showed the sharpest detail, blue photographs were often featureless and hazy, showing only the white areas of the polar caps and occasional clouds along or near the edges of the planet. Two theories have been advanced to account for this. One suggests that the material of Mars's surface was such that it absorbed blue light almost completely. It was known, from the characteristic red color of the planet, that most of its surface reflected red light. The other theory suggests that the blue haze resulted because the Martian atmosphere was opaque to blue light. If blue light were widely scattered in the planet's atmosphere, we should see only its bright atmosphere on photographs that record blue light only.

The most likely explanation—the scattering of blue light in the Martian atmosphere—ran into some difficulty, however, in terms of what was known about the density of the atmosphere. Atmospheric pressure on the earth's surface will raise a column of mercury in a vacuum about thirty inches. This figure, representing our average sea-level pressure, is arrived at by use of the familiar mercurial barometer, and may also be expressed in millibars or in pounds per square inch. No matter what standard is used

**Mars, in the background, is fifty million miles distant. Its size, compared with the moon's, illustrates difficulty of our learning about planet only from telescopic observations.**


Longitude 0°
Longitude 48°
Longitude 96°
Longitude 128°
Longitude 169°
Longitude 201°
Longitude 239°
Longitude 260°
Longitude 308°
Longitude 348°

**Rotation** of Mars, its polar caps evident, is seen, *above.* Longitude given for each image is that at planet's center.

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**Dr. Nicholson**, the regular author of this column, is also Chairman of The American Museum-Hayden Planetarium.

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for the measurement, however, it always represents the force exerted by the atmosphere on a given unit—a measurement of the piece, or column, of air that lies above the measuring instrument. On the surface of Mars, the atmospheric pressure can probably be no more than about 1.5 inches of mercury, comparable to the earth's air at an altitude of about ten miles. It did not seem possible that an atmosphere so thin could be effective as a scattering agent. While the earth's air is much more dense at its surface than is that of Mars, it does transmit some blue light, although the color of the sky shows how much blue it scatters.

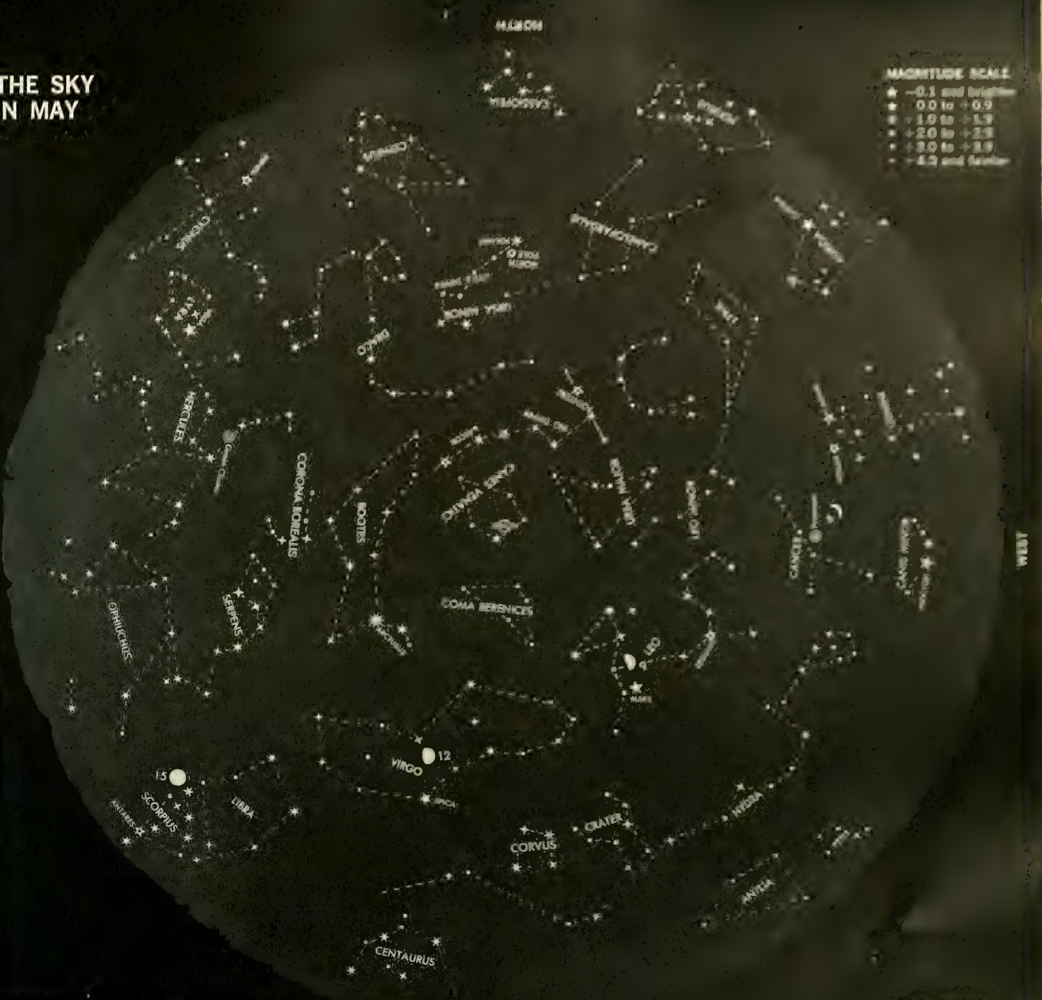
It seems difficult to believe that the atmosphere of Mars could be almost completely opaque to blue light, unless its composition is radically different from what we suppose. It is known that the atmosphere contains about eight times the percentage of carbon dioxide present in earth's atmosphere, and there is some evidence that it contains small amounts of oxygen, water vapor, and argon. Beyond that, we presume that the principal gas in the Martian air is nitrogen, as it is in the air on earth. By volume, the air on Mars probably contains over 98 per cent nitrogen, as compared to 78 per cent in earth's air.

Equally as mysterious as the blue haze that obscures photographs in blue light is the occasional "blue clearing." At rare times, usually close to the time of a Martian opposition, photographs in blue light show as much surface detail as yellow photographs, and almost as much as photographs in red light. This phenomenon lends further credence to theories of an atmosphere, or an atmospheric layer, that is opaque to blue and violet light, but that suddenly and briefly becomes transparent. The nature of this scattering layer is completely unknown.

ASTRONOMERS are eagerly awaiting the approach of Mariner IV to Mars this summer. When the spacecraft passes some 5,400 miles from Mars about July 14, several interesting experiments will be performed that should add immensely to our knowledge. For example, one experiment may provide more definite information on the density of the Martian atmosphere. By testing the effect of the atmosphere on radio transmission passing through it from Mariner IV to the earth, it may be possible to determine if that atmosphere contains layers of ionized gas. Even more interesting to the non-astronomer will be the photographs the spacecraft will, hopefully, send back to earth.

From Mariner IV, the planet will appear to be about 36 degrees in angular size against the sky, or close to 5,000 times larger than it appears from earth when in an optimum viewing position. The electronic cameras on Mariner IV are expected to produce pictures that, when received on earth, should reveal features on the surface of Mars as small as ¼ mile in diameter. In other words, we may expect photographs that resolve surface details on Mars about as well as our best telescopic photographs have resolved the surface of the moon. We can guess that the pictures of Mars from Mariner IV may not solve all of the present mysteries concerning the planet. They will, however, certainly add immeasurably to the meager knowledge of its surface that has been collected over three and a half centuries of viewing and photographing Mars telescopically.

# THE SKY IN MAY


NORTH
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
CASSIOPEIA
CYGNUS
LYRA
DRACO
URSA MINOR
CAMELOPARDALIS
HERCULES
CORONA BOREALIS
BOOTES
CANES VENATICI
URSA MAJOR
LEO MINOR
CANCER
CANIS MINOR
EAST
WEST
OPHIUCHUS
SERPENS
COMA BERENICES
LEO
9
MARS
VIRGO
12
SPICA
15
SCORPIUS
ANTARES
LIBRA
CORVUS
CRATER
HYDRA
ANTLIA
CENTAURUS
SOUTH

| | |
|---|---|
| New Moon | May 1, 6:56 A.M., EST |
| First Quarter | May 8, 1:20 A.M., EST |
| Full Moon | May 15, 6:52 A.M., EST |
| Last Quarter | May 23, 9:40 A.M., EST |
| New Moon | May 30, 4:13 P.M., EST |

**TIMETABLE**

| | |
|---|---|
| May 1 | 10:00 P.M. |
| May 15 | 9:00 P.M. |
| May 31 | 8:00 P.M. |

(Local Mean Time)

May 2: Jupiter is close to the day-and-a-half-old crescent moon at 7:00 P.M., EST. Although both are close to the sun and set shortly after sunset, you may see Jupiter, about a half hour after sundown, just above the upper tip of the moon's crescent. Jupiter is occulted by the moon from parts of the Southern Hemisphere.

May 4: The Eta Aquarid meteor shower reaches maximum about midnight. Although this is a modest shower (hourly rate about 20), the meteors are fast and bright. The radiant is in the region of Aquarius just below the head of Pegasus, above the eastern horizon, from 4:00 A.M. on. There will be no moon to interfere with viewing.

May 6: Mercury is at greatest westerly elongation, its farthest angular distance from the sun in the morning sky. This is an unfavorable elongation, however, because Mercury is only about 10 degrees high at sunrise.

May 9: Mars is in conjunction with the moon at 3:00 P.M., EST. On the evening of the 8th, it is some distance to the left (east) of the first quarter moon. On the 9th, it is much closer to the moon, appearing below it and to the right (west).

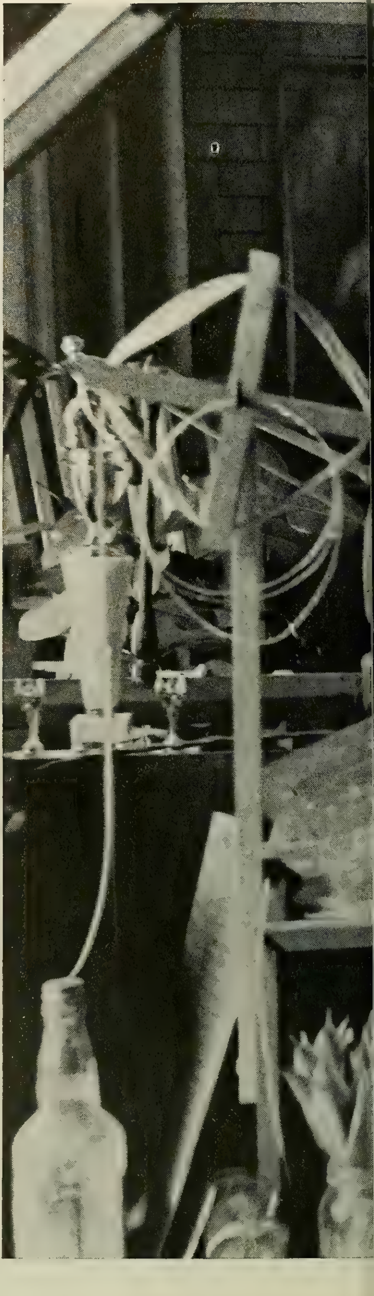
May 24: Saturn is close to the last quarter moon in the morning sky—to the left and above it—from about 2:00 A.M. Conjunction is at 10:00 A.M., EST.

May 30: Jupiter is in conjunction with the sun at 2:00 A.M., EST, and moves into the morning sky. A total solar eclipse occurs today. The path of totality stretches across the Pacific Ocean from the northern tip of New Zealand (where the sun rises fully eclipsed) to the coast of Peru (where the setting sun is eclipsed). Although this is an eclipse of relatively long duration (totality lasts up to 5 minutes 16 seconds), only a few desolate islands of the mid-Pacific lie along the path of totality. The partial eclipse is visible over a much larger area of the Pacific Ocean and its adjacent lands, including Central America, Lower California, the southern region of Arizona and New Mexico, and Cuba.

Only Mars, located in Leo, is prominent this month—in the south about sunset and setting soon after midnight. It will dim from magnitude zero to +0.5. Saturn, in Aquarius, will be visible for several hours before dawn, in the east. On the 24th of the month the moon may prove helpful in locating it.

An orang-utan sits among paints and props under the broad leaves of *Ficus altissima,* while in dim painting a decorative nude looks on.

# Nature



In the theater one can count on a high percentage of failure, but at The American Museum of Natural History in New York, when a show goes on, it is in for a long run. The designing and follow-through of the design—from first rough sketch to completed exhibit—frequently continues for years with the art and scientific staff checking accuracy and detail. In the Museum's exhibition department one comes across flora and fauna juxtaposed and consorting with strange and unlikely companions, all awaiting their cues in an atmosphere of behind-the-scenes chaos and excitement—for a production that will remain open.

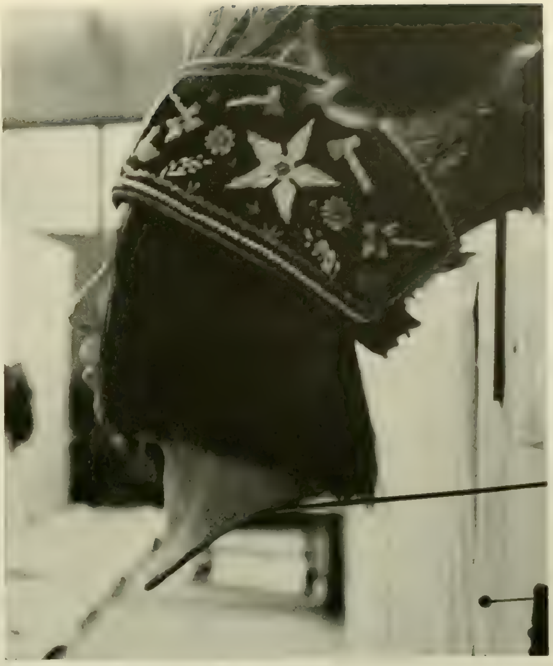
# Behind the Scenes

Photographs by Gert Berliner

# "The world's a stage on which all parts are played."

Artist's preliminary sketch of Indian paddling a canoe looks through a tracing of a transportation drawing for new Indian Hall.

Indian manikin, under plastic, wears costume of the Plains Indians in sun dance ceremony, for exhibit in future Indian Hall.

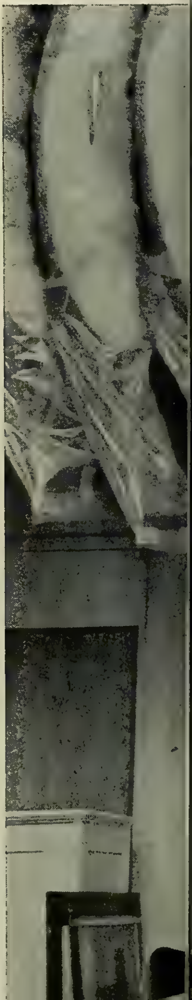


Iroquois Indian headdress, with the design worked out in beads, is to be shown in the Museum's Woodlands Indian exhibition.

Peering from under plastic covers, two Indians costumed for their pipe ceremony will be a part of Plains Indian section.

## "...scene of man; A mighty maze! but not without a plan."

Casts on shelf were made in the field for the taxidermist's reference, above a torso now in the Hall of the Biology of Man.



Porpoises in plastic covers await their act, hanging above a gibbon. On wall is diagram for past Man in Space project.

Planned and artistic disorder marks this desk as the work area of specialized and busy craftsman.

These legs, when reunited with the other half of Indian brave, will be in Museum's new Indian Hall exhibit.

# Water, History, and

## Irrigation has posed problems for millennia

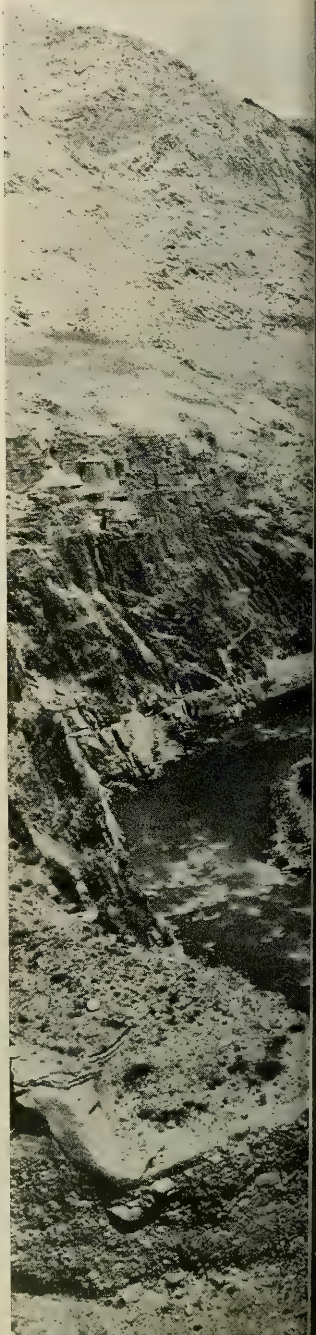
By George C. Taylor, Jr.

Water—underground or in rivers, lakes, and glaciers—has for millennia markedly affected the trend of human affairs throughout the world. In the Indus region of southwest Asia, it has been a vital factor in man's social and economic evolution. Stretching in a great arc around the northern and western flanks of the Indian subcontinent, this vast region of mountains and plains covers some 350,000 square miles, all of which are drained by the network of the Indus River and its tributaries.

The geologic evolution of the present river system probably dates back to Early Tertiary time, about 65 million years ago, and began with folding and upthrust, first of the mountain chains of the Hindu Kush and Himalaya, north and northeast of the Indus region, and later of the Kirthar and Sulaiman ranges in the west. Concurrent with these mountain-building movements, a great trough began to subside in the earth's crust between these mountain belts and the Indian peninsula to the south. The upbuilding of the mountain chains continued during Tertiary time, through the Pleistocene, and on into the Recent Epoch, until the summits of the higher peaks rose to their present heights of 25,000 feet or more above sea level. Meanwhile, headwater torrents of the Indus and its tributaries cut deeply into the soft rock strata of the rising mountains and carved an intricate network of intermontane valleys, canyons, and gorges, many of which are now several thousand feet below the mountain tops. The erosive action reached its climax in the Himalaya and the Hindu Kush, where weathering and running water stripped away thousands of cubic miles of rock. The eroded debris, transported downstream by river flow, was laid down as an alluvial fill in the subsiding trough—in fan-shaped aprons of interlocking gravel near the footslopes of the mountains and, farther downstream, in the vast, flat, and seemingly endless plains of the Indus that slope gently southwestward to the Arabian Sea. Ultimately, this aggraded fill of gravel, sand, silt, and clay extended across a lateral distance of 200 to 400 miles, and almost a thousand miles from the Himalayan foothills to the Indus Delta. Near the edges of the trough the fill accumulated to depths of several hundred feet; over its center it attained a thickness of several thousand feet.

Most of the present morphology of the Indus region resulted from the activity of mountain-building forces, weathering, and running water. Glacial ice has played an equally important role in the evolution of the existing land forms, particularly in the Himalaya and the Hindu Kush, where upper slopes are scarred everywhere by icework. During the Pleistocene, these mountains bore numerous valley glaciers, some of which coalesced in continuous ice sheets, or piedmont glaciers. At times, ice tongues descended valleys to altitudes as low as 6,000 feet, whereas present Himalayan glaciers all lie above 13,000 feet. At least three, and possibly four, glacial episodes left their records in Himalayan valleys and intermontane basins as moraines, till sheets, glacial lake beds, and river terrace deposits. These glacial episodes correlate with pluvial cycles of high stream discharge and heavy sedimentation in the Indus Plain. Correspondingly, the interglacial episodes are related to the drier interpluvial cycles, during which streams of the Indus system deeply eroded older alluvial deposits.

Archeologists have discovered evidence of primitive man's occupation of the Indus region in a number of prehistoric sites in Kashmir and Punjab, mainly on river terraces along the Soan River between the Himalayan foothills and the Indus River, and



**Indus Valley** extends for a thousand miles from Himalayas to Arabian Sea.

# the Indus Plain

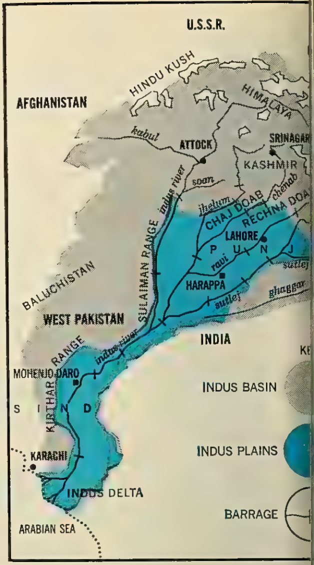
**Well** is in paved courtyard in ruins of Mohenjo-Daro in Sind, *above;* at same site is covered drain, *below,* both remnants of Harrapan culture.

along the Indus itself between Attock and the mouth of the Soan. The oldest historic culture recorded in the region is the Harappa civilization, named for its principal archeological site on the Ravi River in Punjab. Reaching full flower in the time of Sargon of Akkad in Mesopotamia about 2300 B.C., the Harappa civilization may have had its beginnings as long as 4,500 years ago. The Harappans probably belonged to the same Dravidian stock that today forms the population nucleus of the southern part of the Indian peninsula. After a period of decline that was probably the result of a compound of man-made and natural disasters, Aryan invaders from central Asia finally overwhelmed the Harappans about 1500 B.C.

The Harappan culture covered a far wider geographic range than any other known preclassical civilization, for archeological sites have been found scattered through the plains of the Indus from near Rupar at the base of the Himalayan foothills to the Indus Delta—a distance of almost a thousand miles. The wide distribution of the sites and the characteristic uniformity in arrangement and physical design suggest that the Harappan people built a relatively sophisticated and disciplined socioeconomic order.

The close association of their town and city sites with the river system of the Indus Plain indicates that the Harappans were essentially lowland flood-plain dwellers and a riverine people. Of the more than fifty sites that have been identified, most are located along active or abandoned channels of the Indus River in Sind and near its tributaries, the Ravi, Sutlej, and Ghaggar in Punjab. The town planners and builders probably chose the original sites because the rivers formed routes for the movement of goods and for social interchange among the riverine communities; they supplied water for the manifold needs of the sophisticated urbanites of Harappa and Mohenjo-Daro, as well as for residents of the smaller towns; they furnished water for irrigation of wheat, barley, and vegetable crops; they sustained food—fish, game, waterfowl—and they were defense lines against raiding nomads.

As is characteristic of men who occupy flood plains, the Harappans suffered from all the vagaries of the rivers along which they chose to live. There is evidence, for example, that the engineers and artisans of Mohenjo-Daro repeatedly shored up or rebuilt the city walls as a result of the ravages of the Indus as it swung in its channel and cut laterally against its banks. Harappa was apparently no less subject to the whims of the Ravi. The ruins of several large Harappan towns in Sind, along the banks of an abandoned channel of the Indus, are now several miles from the present, active river channel. It has been surmised that the towns declined and died following such shifts in the river. Moreover, gradual accumulation of sediment in river channels and adjacent flood plains near these cities and other Harappan towns necessitated repeated raising of protective walls, dikes, and building foundations, and the constant adjustments of municipal sanitary drainage systems. At Mohenjo-Daro there is evidence that the Indus flood plain built up more than fifteen feet during the occupancy of the city. Concurrent with siltation of the flood plain, capillary water from rising water tables sapped and undermined brick walls and foundations, which, as a result, required the construction and maintenance of protective seepage drains, such as those at Harappa.



**Moguls** may have introduced came driven Persian water wheel, righ

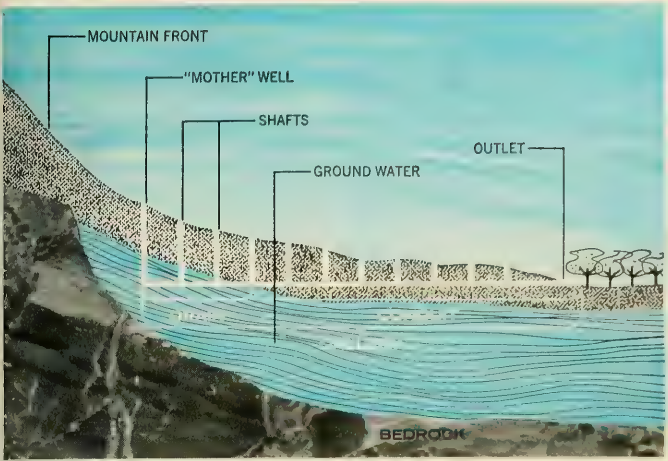
**Cattle** and water buffalo cross tract of salinized land in the Bari Doab.

Irrigation may not have been genrally necessary during the early tages of Harappan history, when rainall was relatively abundant. Later, owever, as the climate grew drier, irigation was most certainly required o sustain agriculture, and was probbly practiced near the rivers of the ndus Plain, although all traces of diersion works, distribution canals, and ield irrigation systems have been obiterated by subsequent erosion and ggradation of the Indus and its tribtaries. However, pictorial representaions found on Harappan clay seals how water-lifting devices similar to the Egyptian shadoof (a counterpoised sweep), indicating that this method of irrigation was probably used at least locally. The extensive granaries found at Harappa and Mohenjo-Daro also suggest that large food storage facilities were needed to provide for shortages during prolonged droughts or seasonal deficiencies in water supply for irrigation.

From the fourth century B.C. until the Mogul period of the sixteenth to eighteenth centuries, irrigated agriculture in the Indus Plain was limited largely to the low-lying riverine tracts (active flood plains) where flood irrigation, locally known as *sailab,* was practiced along rivers of the region. Crops, mainly wheat and other cereals, were planted in moist lands exposed by the receding waters of summer floods. Under *sailab* irrigation, cultivated lands maintain their productivity indefinitely, and the method is still practiced in the active flood plains, most of which are not served by canals. Some irrigated agriculture was practiced locally from dug wells in the higher interfluvial tracts known as doabs. In pre-Mogul times, however, these areas were reserved chiefly for grazing. A system of permanent land

**Shalimar Gardens** near Lahore, built by the Mogul emperor Shah Jehan in 1637, were irrigated by inundation canals.

**West Pakistan** farms, *below*, were often at a subsistence level before modernization began on water supply systems.



**Moguls** may also have introduced the *kharez*, seen in cross section. System may yield over two cubic feet of water per second, but often needs cleaning.

**Inadequate wells**, such as one above, and waterlogging present dual problem.

tenure gradually evolved in and near the riverine tracts in Punjab, with peasant proprietors living in closely knit village communities. This system has survived despite successive waves of invaders, including the Jat and Gujar tribes, later Moslem conquerors from central and western Asia, and more recently the Sikh conquest in the pre-British period. Throughout this 2,000-year span, irrigation works were built repeatedly by the occupants of the region, only to be destroyed by invaders or by the ravages of floods and siltation. During this time, however, there is no substantial evidence that the twin problems of waterlogging and salinization, such as now exist in Punjab, ever presented any great threat to irrigated agriculture. Presumably, the upbuilding or aggradation of flood plains in the riverine tracts kept pace with rising water tables, which may have been induced by irrigation, so that soil fertility and favorable salt balance were maintained.

Underlying the plains of the Indus is a vast ground-water reservoir, which is sustained and recharged largely by infiltration from rivers of the Indus system and by leakage from canal diversions. This reservoir has figured importantly in the water economy of the Indus region for 2,000 years or more, as mention is made of the use of wells in the great Hindu epics *Mahabharata* and *Ramayana*, which were presumably composed in the period immediately prior to the beginning of the Christian Era. Wells at some ancient Hindu temples have been used for hundreds of years for ritual ablutions. Many of these wells are essentially large-diameter (50 to 100 feet) infiltration pits dug down to the water table. They are square or rectangular and are bordered by the stone- or brick-terraced slopes, or ghats, used by worshipers in their devotions. In the "bar uplands" of the doabs remote from the rivers in the Indus Plain, hand-dug wells, with hand lines and buckets, have provided essential water supplies for domestic and livestock use since time immemorial. In areas where the water table is less than 50 feet below the surface, small-scale irrigation is also practiced now, as it has been for centuries. A *mote* (leather bag, commonly of buffalo hide) is attached to a rope that is passed over a pulley, and a yoke of bullocks or a camel raises and lowers it to the water. The quantities of water obtained from single wells by this method of lift generally range from about 800 to 2,000 gallons per hour, depending on the water level and the activity of the well operator. A second water-lifting device, still widely used in Punjab and Sind, is the Persian water wheel, which reportedly was introduced by the Moguls from Iran. It consists of an endless chain of earthen pots or small metal buckets that are passed over a wheel with a horizontal axis. A camel or bullocks push a horizontal bar around a vertical shaft geared to the wheel, and thus raise the water. Because of its greater efficiency, the water wheel can lift somewhat greater quantities of water than can be obtained by bullocks and *mote.*

There are still records of groundwater development in the sixteenth and seventeenth centuries during the period of Mogul domination. Mogul princes constructed many wells for military, household, and irrigation purposes at forts, palaces, and mausoleums near Lahore, Srinagar, and elsewhere in Punjab and Kashmir. Intricate floral mosaics, faïence, and carved marble and sandstone decorate the walls and draw works of some of the palace wells. Other wells were used for cooling the air of subterranean living quarters to which Mogul princes and their ladies repaired to escape the scorching heat of the Indian summer. It is reported that in these water-cooled chambers they sipped sherbets made from ice delivered by post horsemen who rode in relays from the glaciers of Kashmir.

The Moguls also are believed to have imported the *kharez*, or *ghanat* (infiltration gallery), from Iran and Afghanistan into the Indus region. The *kharez* is constructed by sinking a series of vertical shafts spaced at intervals of about 100 feet in a line approximately parallel to the slope of the water table and as much as several miles long. Underground and between the shafts, horizontal drifts are excavated and connected to form a gallery whose grade is slightly less than that of the land surface and the water table.

**BARRAGES are built at various river sites to control canal water. The Rasul headworks on the Jhelum River, *above*, diverts flow for Lower Jhelum Canal.**

**SOUTH BRANCH of Lower Jhelum Canal is in Chaj Doab. Here the rate of flow**

The first and deepest shaft, known as the "mother" well, and the next few shafts in the line reach the water table and tap the ground-water body. The up-gradient part of the gallery thus functions as a drain fed by the ground-water body, but the down-gradient part is simply a conduit carrying water by gravity to the land surface for irrigation or other use. Such *kharezes* may develop individual flows of as much as two cubic feet per second or more, but caving necessitates frequent cleaning to maintain flow. Many of these structures built in alluvial valleys of Baluchistan during the Mogul times are still in operation, but in the plains of the Indus their effective use was apparently impossible, owing to the prevailing flat gradients of both the land surface and the water table.

Until the latter part of the seventeenth century, the population in the Indus region stayed relatively stable because of repeated decimation by war, by famine, and by pestilence. The establishment of Mogul domination, however, brought the beginnings of political order and improved conditions of sanitation and food supply, which were further strengthened under the British "raj" in the eighteenth and nineteenth centuries. As a consequence of political stability the population began to increase—slowly at first, but at an accelerated rate during the nineteenth and twentieth centuries. The expanding population required an augmented food supply, which meant the intensification of irrigated agriculture, particularly in Punjab and Sind. The pressure of population on the land is reflected in the types and relative sophistication of the canal systems devised for irrigation.

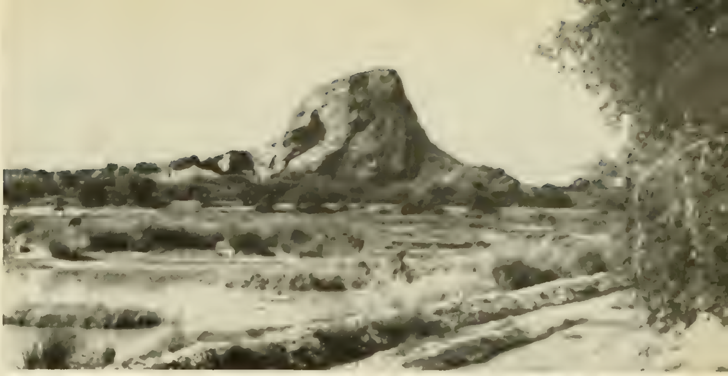
Canal irrigation, in a modern sense, did not begin until the seventeenth century, with the construction of so-called inundation canals in the Punjab. These could divert water from rivers during periods of relatively high stage for distribution to bar-upland areas bordering the flood plains. The first canals of this type furnished water for the parks and gardens of Mogul princes. Typical are the Shalimar Gardens near Lahore, laid out in 1637 by the order of the Mogul emperor Shah Jehan. Because of the success of these canals, others were constructed for general agricultural purposes. By the middle of the nineteenth century a rather extensive network of inundation canals was in operation in Punjab, with the maximum development concentrated along the Sutlej and Chenab rivers. During the same period, extensive irrigation development took place in Sind by inundation canals that diverted water from the Indus. Because they could command larger parts of the doabs, divert water through a significant range of river stages, and maintain irrigation deliveries for a considerable part of the year, these canals represented a distinct advance over the ancient *sailab* methods. Such inundation canals could function, however, only during periods of relative high flow, so irrigation was limited to the summer high-water season and to relatively narrow belts near the rivers.

THE final stage in the evolution of irrigation systems in the Indus Plain came about the middle of the nineteenth century with the introduction of "perennial" canals. Permanent diversion works known as barrages, or headworks, were constructed at strategic sites on the rivers to place the inundation canals under weir control. By raising water levels, the barrages allowed larger diversions from the rivers than were possible with the canals, especially during the winter season, when low flows could be exploited. Thus, irrigation was extended into the central parts of the doabs, and in many areas the canals operated throughout the year—hence the term perennial. They were carefully designed as to width, depth, and downstream slope; the silt-laden water would move just fast enough so the silt would not choke the canal, but not fast enough to cause erosion. Today, the canal systems of the Indus Plain, including distributaries, have an aggregate length of over 10,000 miles.

Each year the Indus River and its principal tributaries—the Jhelum, Chenab, Ravi, Beas, and Sutlej rivers—bring an average of about 170 million acre feet of water into the Indus Plain. About half of this water flows to the sea, but the rest is diverted into canal systems that now irrigate about 33 million acres annually. This constitutes what is probably the largest essentially continuous block of irrigation development in the world. It forms the economic base for a population of some 35 million people, of whom 23 million depend directly on agriculture for a livelihood.

As canal irrigation involves diversion and redistribution of surface runoff, some disruption of the natural hydrologic regimen of the Indus Plain was inevitable. Moreover, the nineteenth-century British engineers, concerned with construction of the canal systems, early recognized the potential hazards of salinization and waterlogging that could result from irrigation and also saw the ultimate need

occasionally may be greater than nine or ten thousand cubic feet per second.



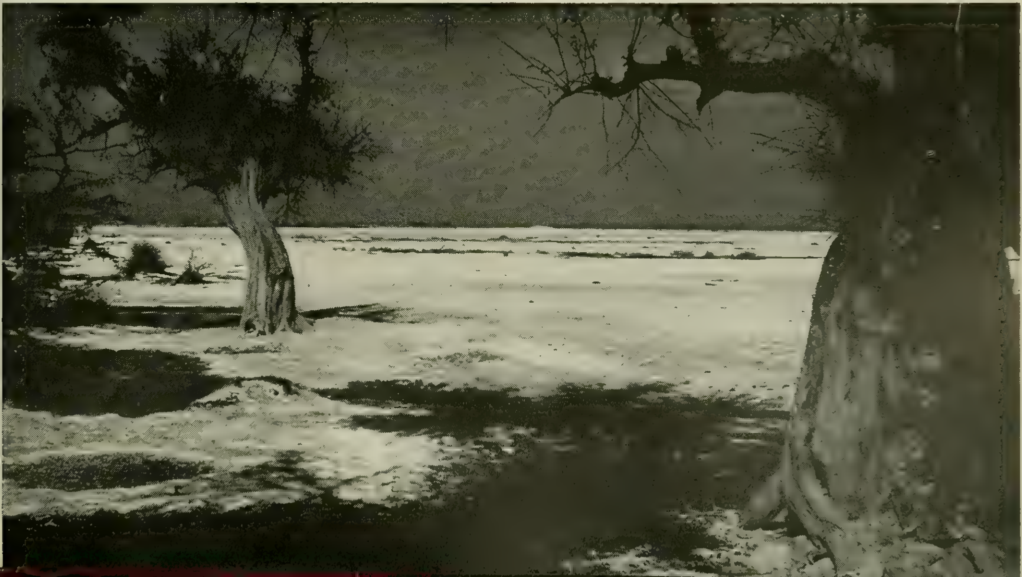
**Waterlogging**, *above*, was common in Rechna Doab, where drainage projects are now under way. Hill is of bedrock, protruding through the alluvial fill.

to provide for adequate subsoil drainage and control of the water table. With these hazards in view, they established, as early as 1870, a program of hydrologic observations—including measurements of stream discharge and canal diversions and, more particularly, of ground-water levels—that have been continued to the present.

But, in spite of the awareness of salinization and waterlogging, these two dangers were largely ignored in irrigation development planning through the latter part of the nineteenth century and in the early decades of the present century. This indifference was probably the result of a compound of hydrologic, economic, and political factors. At that time, for instance, the water table was relatively far below the land surface (as deep as 90 feet in some parts of Punjab in 1900), which led to procrastination in planning for drainage and water-table control. The problem of a growing population, with the attendant chronic shortages in food grains and the recurrent famines. demanded immediate solution. Consequently, emphasis was placed on intensified agricultural production to be made possible by the construction of new canals and the expansion of lands under irrigation. Political unrest and agitation for independence during the early decades of the twentieth century also led the British raj to seek short-term solutions to then current economic difficulties rather than to attack long-term hydrologic problems.

As the first twenty years of the present century passed by, the water table beneath the Indus Plain rose relentlessly closer to the land surface as more and more water leaked underground as a natural concomitant of expanding canal systems and intensified irrigation. By 1925 the twin ravagers, waterlogging and salinization, had already begun to take their toll in diminished agricultural production in several parts of the plains. The day of reckoning had finally arrived, and water managers of the Indus irrigation system at last took stock and began to lay plans for drain-

**Salt incrustation** covers the ground in the Rechna Doab near Lahore, and is caused by excessive salinization as a result of insufficient drainage. The phenomenon has been referred to by one writer as an "accursed mockery of snow."



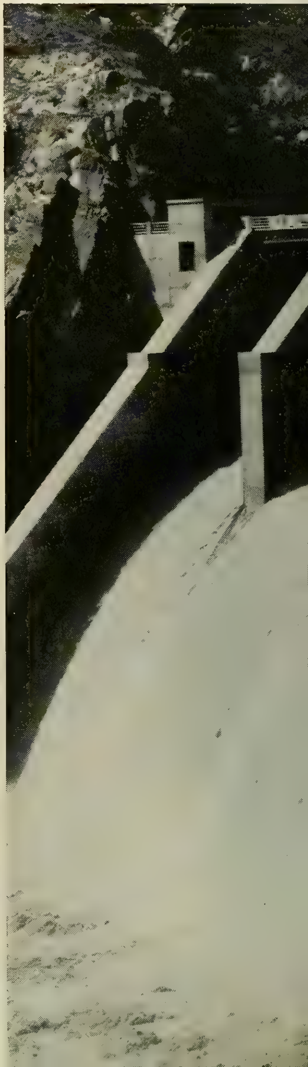
age and for water-table control. Although the problem was now clearly in focus, engineering planners of the 1920's and 1930's were at first overwhelmed by the magnitude and technical complexity of the task before them and later dismayed by the enormous sums of money that would be required for adequate engineering control works.

Meanwhile, the inexorable rise of the water table continued, and more and more productive agricultural land was lost to effective use each succeeding year. Between 1930 and 1960, for example, agricultural land went out of production at rates variously estimated at between 50,000 and 100,000 acres per year. During the 1930's attempts were made to control waterlogging by building many miles of artificial drains and by improving the natural drainage channels. These measures proved largely ineffective. In the early 1940's a major reclamation project was undertaken in Chaj and Rechna Doabs, and some 1,600 wells were put down at various intervals along the main canals and their distributaries. Recognizing that leakage from the canals was the major cause of the rising water table, the plan called for intercepting the leakage by pumping from the wells and returning the water to the canals. The project, however, never became effectively operative, largely because of power shortages during World War II. Very shortly thereafter came the vast socioeconomic disruption caused by the 1947 partition of British India and the creation of the independent states of India and Pakistan. Aside from the human suffering and privation caused by the shifting of religious minorities, partition brought about a complete realignment of political and economic structures. Most of the British engineers who had formerly managed the Indus irrigation system departed, and their Hindu colleagues opted for citizenship in the new Republic of India. Furthermore, the new frontier between West Pakistan and India, demarcated largely on the basis of religious constituencies, haphazardly bisected the hydrologic basin of the Indus River and thoroughly disorganized the formerly smooth operations of the Indus irrigation system. Consequently, partition set in motion a whole chain of water allocation disputes, leading in some cases to armed border clashes between the two countries. As the bulk of the Indus irrigation system lay in Pakistan, it fell to the lot of a new generation of Pakistani engineers and scientists, directed by a few "old hands" from prepartition days, to cope with the steadily deteriorating agricultural economy brought about largely by waterlogging and salinization, and to reorganize the severed irrigation system.

By 1951 local and international experts recognized that ultimately the waters of the Indus system would have to be adjudicated between India and Pakistan to avert the threat of a full-scale war. An international water commission was appointed to review the problem. After nine years of negotiations, the commission finally came to an agreement, and in 1960 the Indus Water Treaty was signed. The treaty gives India the rights to the waters of the Ravi, Sutlej, and Beas rivers, leaving the flow of the Chenab, Jhelum, and Indus to Pakistan.

In 1953 the government of Pakistan had signed an agreement with a predecessor of the U.S. Agency for International Development (AID) to make a comprehensive investigation of the cause and effect relationships between irrigation practices and the natural hydrologic situation of the Indus Plain, with particular emphasis on the Punjab region. The work was initially carried on by Pakistani personnel of the Irrigation Branch, West Pakistan Public Works Department, with the assistance of AID technical advisors. In April, 1960, the technical staff and the work were transferred to the newly established Water and Soils Division of the West Pakistan Water and Power Development Authority (WAPDA). The investigative work done during the past ten years indicates that virtually all the Indus Plain is underlaid to depths of 1,000 feet or more by alluvial sediments that are saturated with water to within a few feet of the land surface. In the saturated alluvium, which is composed of materials ranging from medium sand to silty clay, large-capacity wells that yield as much as 1,800 gallons a minute or more can be developed at almost any site. The ground water in Sind is generally of such poor quality that it is practically unusable for irrigation. Its content of dissolved salts is so high that the water actually inhibits plant growth. Beneath about two-thirds of Punjab, however, water of a quality usable for irrigation saturates the alluvium to a depth of 500 feet or more. The volume of usable ground water in storage is computed to be about two billion acre feet. Studies of water levels indicate that while canal leakage is the principal cause of the present subsurface drainage problem, it is also the major component of groundwater recharge.

The hydrologic investigations point up the feasibility of utilizing groundwater withdrawals from tubewells (a

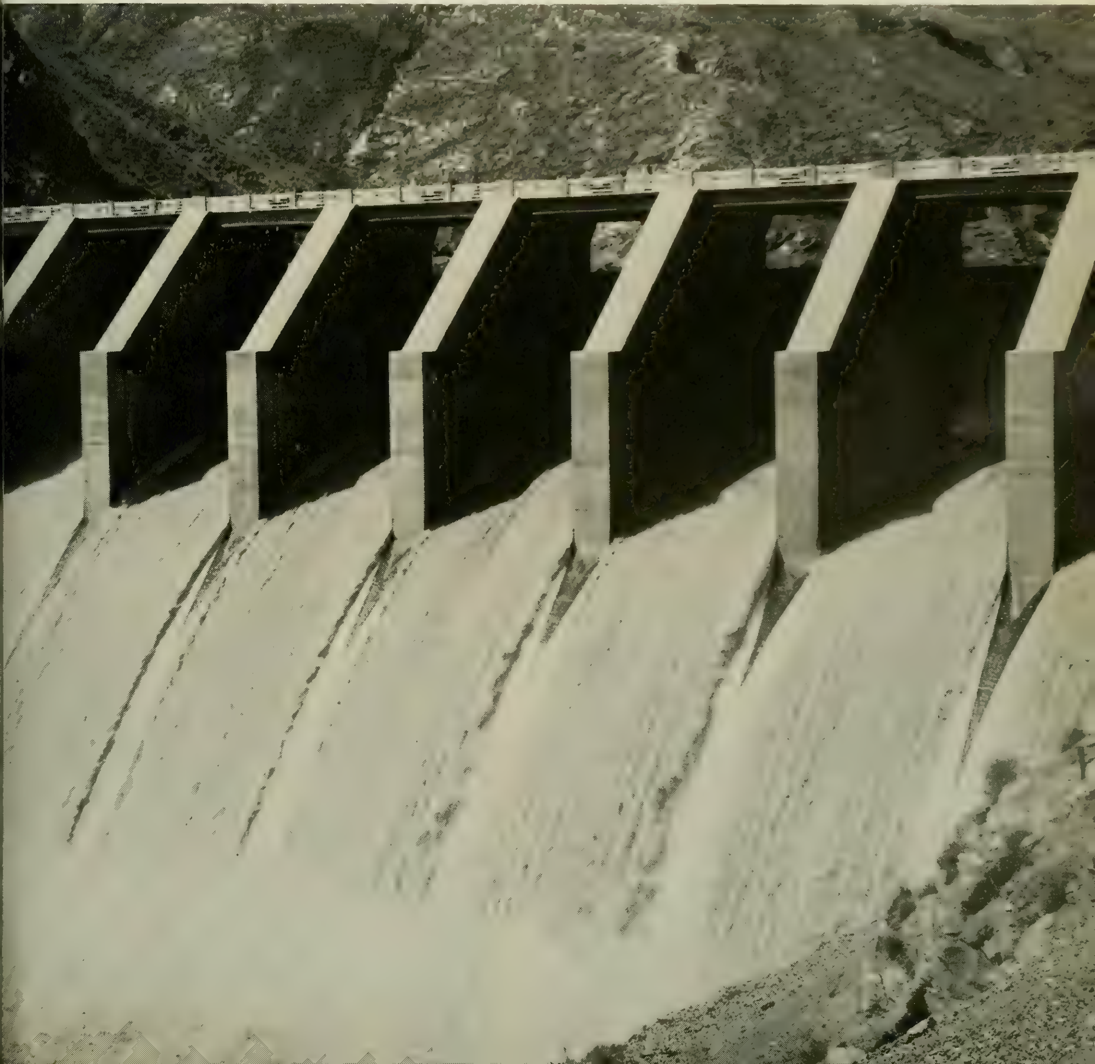


**Warsak Dam**, the largest in Pakistan, is constructed across the Kabul River in northwestern part of the country.

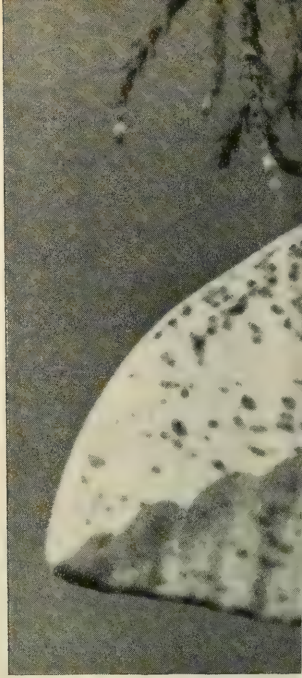
term used in Pakistan and India for what would be called a drilled well in the United States) for the dual purpose of providing (1) a much needed supplemental irrigation supply to augment presently inadequate surface-water supplies, and (2) subsurface drainage by lowering the water table and thus helping to reduce waterlogging and salinization. Because of the natural limitations and inadequacies of sites for surface reservoirs to store summer runoff, most of which is now wasted to the sea, the vast underground reservoir of the Indus Plain offers the most promising storage facility for management of available water supplies. By pumping from wells for irrigation and drainage, ground-water levels are depressed and capacity is created for the underground storage of surplus surface runoff that can be diverted underground by allowing it to leak through the canal system.

Beginning in 1961, two large-scale tubewell irrigation and drainage projects were placed in operation in Chaj and Rechna Doabs, and these have already demonstrated their effectiveness. Between 1961 and mid-1963, for example, the water table was lowered an average of more than three feet in a 1,350,000 acre project in Rechna Doab. Construction of similar projects in the future is planned at a rate of about 1,000 tubewells per million acres per year. Eventually, about 33,000 wells will be required to serve all the Indus Plain.

As has been the case for millennia, the basic economic and social structure of the Indus region is largely dependent on irrigated agriculture, and will continue to be so for many years to come. The durability of this structure will depend substantially on the successful solution of the waterlogging and salinity problems and on the effective management of the water supplies now available in the Indus Plain.



**Wingspread** of an imperial moth (*Eacles imperialis*) can be five inches across. A newly emerged female is at right.



# Life Cycle of Seclusion

## Adults appear one year after eggs are laid

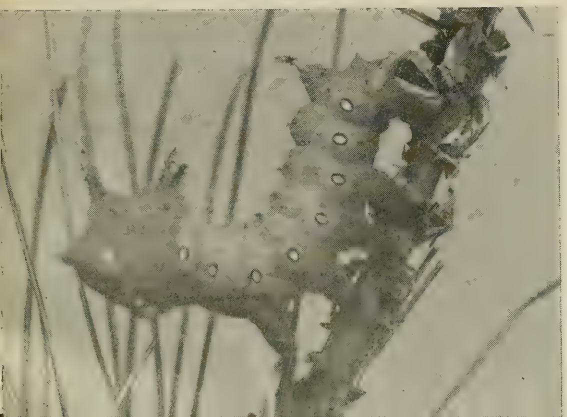
By Ralph J. Donahue

In the subfamily Citheroniinae of the family Saturniidae there is a large yellow species of moth that entomologists have named *Eacles imperialis*, popularly known as the imperial moth. While this bright moth can scarcely be called as common as the white-lined evening sphinx, it is often found over the eastern third of the United States. Sooner or later, most moth collectors will add one or more specimens of this species to their collections.

Many people living within the range of these insects may be unaware of their presence. Imperial moths usually remain in seclusion during the day and are infrequently attracted to lights at night. Their larvae, however, although camouflaged by foliage, may sometimes be discovered by means of the large, green pellets they excrete, which lie scattered about the ground beneath their feeding sites. While the larvae of many moth species confine their eating to the foliage of one, two, or possibly three kinds of plants or trees, those of the imperial moth have been reported to feed on many trees, including pine, hemlock, juniper, sycamore, hickory, wild cherry, sassafras, sumac, and elm.

The life cycle of the imperial moth takes place over a year's time. Females usually lay their eggs in late June, and it is not until one year later that the adult moth emerges from the pupa. The eggs are laid on the upper leaf surfaces of broad-leaved trees or on the twig bark of needled evergreens. At first the eggs resemble drops of pitch, or resin but they darken in a few days, and the larvae hatch in abou two weeks. The hatchlings are nearly a quarter of an incl long and are usually brownish yellow. Their legs and prolegs are blackish. The caterpillars first eat their eggshells

**Third-molt** caterpillar, three or four weeks old, assumes upraised attitude characteristic of larva sensing danger.



**Imperial moth** larvae feed on many different trees. Thi one defoliates a spreading juniper twig in eastern Kansas

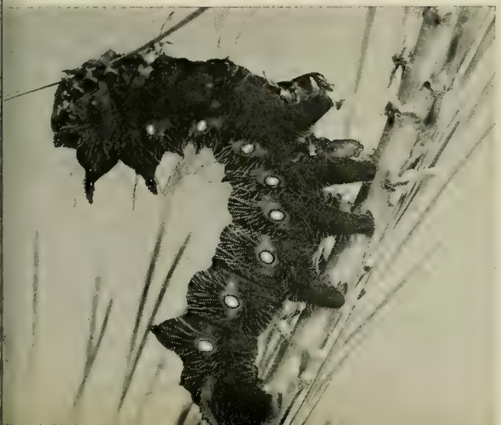
and then they begin defoliating the leaves of their host tree.

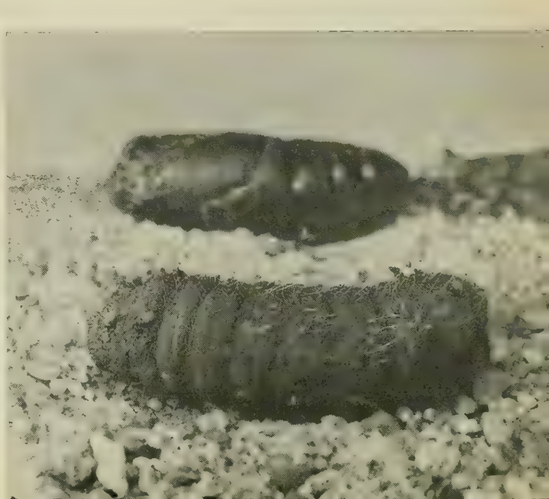
At the time of the caterpillars' first molt, about a week after hatching, the larval color becomes a rich brown. The second molt occurs a week later. At this point the spiracles become whitish and more conspicuous, an effect that is even more apparent with each succeeding molt. Seven or eight days after the second molt (individuals vary), they undergo their third change. If there is to be a variant in larval color, it will show up at this stage. Often, in a group of eight or ten normally brown larvae, there will be one bright-green individual that will remain green through the remaining two molts.

After about eight weeks of development, the larvae are three inches long and as thick as a man's thumb. They stop eating and descend from the trees to the ground. There, before burrowing into the earth to pupate, they expel the last traces of their final meal and begin to contract. Once underground, their bodies continue to contract for about three days, becoming less than two-thirds their original length. Finally the old skin is sloughed off and, without benefit of a silken cocoon, the shining brown pupa is in full contact with the soil.

By June of the following year the pupae have developed into beautiful adult moths—bright canary yellow covered with patches of rust and lilac. Bodies of the females are thicker than those of their mates, and their antennae are more slender. Late on the night of their first day as adults, the imperial moths lift their wings and slip away into the summer dark. Now they are in the final phase of their life cycle in which they find a mate, lay their eggs, and die.

**Larva**, *below*, eats pine needle. Before going underground to pupate, *right*, larva contracts, excreting its last meal.





# Courtship Behavior o

By Theodore Savory

When a male scorpion, false scorpion, or spider meets a female of his species, he seldom supplies her immediately with the spermatozoa necessary to fertilize the eggs. Nearly always there are preliminaries that delay the transfer; forms of behavior that are seen in no other circumstances, and which, by a rather ill-chosen comparison with human custom, are described as "courtship."

Among the non-human animal species, there must be some advantage that has favored the retention and development of such behavior. Among arachnids, courtship is widespread and often complex, so that these animals provide material on which attempts to find an interpretation may hopefully be placed. False scorpions, or pseudoscorpions, are very small arachnids that look like minute scorpions without tails. They live chiefly under fallen leaves, beneath the bark of trees, and in similar places. One of the first accounts of their mating was written by an English zoologist, Wallis Kew, in 1912, but little was heard of the subject again until the publications of Joseph Chamberlin of Oregon in 1931 and Max Vachon of Paris in 1935. The following is based on Vachon's account of the species *Chelifer cancroides*.

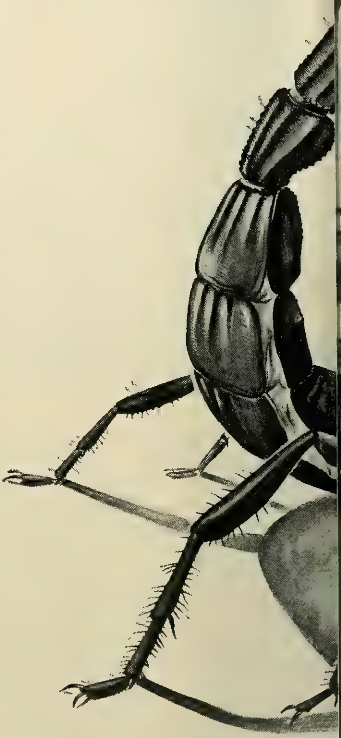
On meeting the female, the male stops and stretches out his palpi. Then he begins to "dance." The tips of his forelegs are brought together, the abdomen vibrates, the palpi are waved. He approaches the female and raises his forelegs, one after the other. Suddenly he lowers his body and touches the ground. A viscous drop exudes from the genital aperture, and as he raises himself it is drawn out into a thin rod. For several seconds he does not move; then he retreats, leaving a drop of semen on the top of this spermatophore. The animals are apart, with the rod between them.

Now the male, squatting, moves his palpi in a slow rhythm, and the female, as if obedient to this signal, rises and stretches out her palpi. She moves forward and carefully adjusts her position so that she sits on the rod, which penetrates her genital orifice. The male seizes her by the legs and shakes her vigorously, so that the drop of semen is shaken off the spermatophore and left inside her. The animals separate, and if they chance to meet again they are likely to avoid one another.

The pseudoscorpion thus introduces a strange process—insemination by means of a spermatophore. This device is a product of the male system, composed of a material that hardens on or after secretion, and it supports the droplet of semen in a suitable position. Its appearance as an accessory in the reproductive process makes the mating of pseudoscorpions essentially distinct from the mating of spiders. It also prompts two questions: first, how do members of other orders achieve insemination, and second, are there significant points of resemblance between pseudoscorpions and spiders?

The second question will be considered first. When the courtship of a sufficient number of different species of both orders has been analyzed and compared, the following details are to be emphasized: there is an immediate reflexive response of the male as soon as an appropriate sense organ, visual or chemotactic, is stimulated by the approach to the female; there is a series of rhythmic and repeated movements, in which the female sometimes takes part; then there comes a moment when the male touches the female. This appears to provide the stimulus necessary for progress, for if the female is of another species, the male ordinarily does not receive the stimulus necessary to make him continue the courtship.

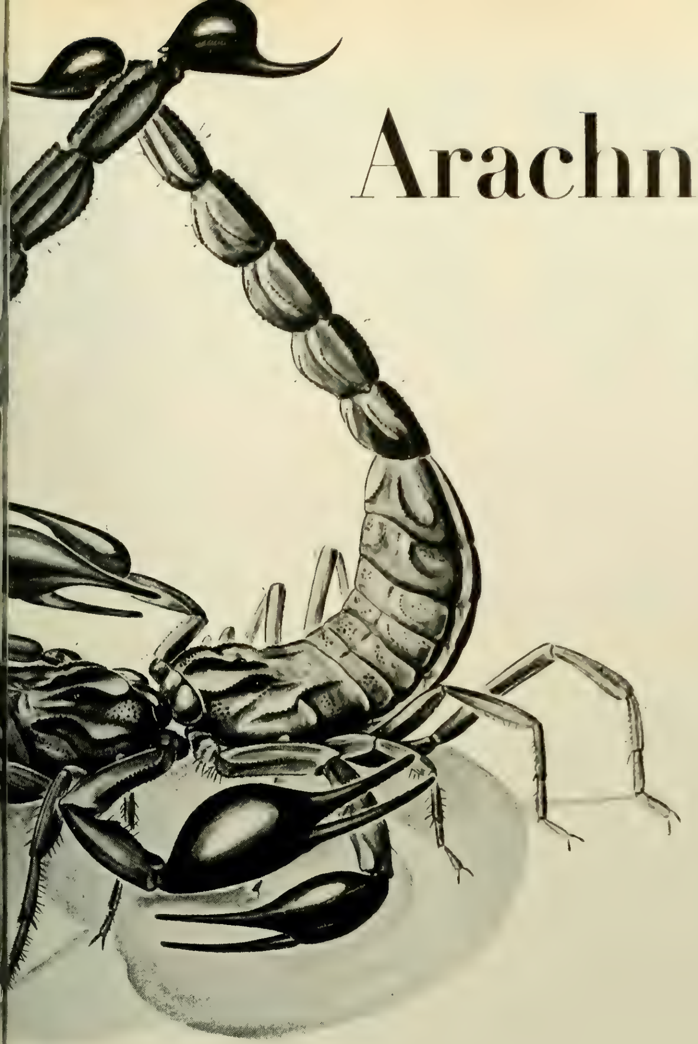
It is important to notice that in all arachnid courtship these three components, or obvious modifications of them, can be detected. In details, there are differences from species to species, and more from family to family; they may be represented only by analogous events in different orders, but the same principles are involved.



Scorpions grasp each other and may walk back and forth for over an hour.

In answer to the first question, regarding methods of insemination, two other orders of arachnids may be considered. The courtship of scorpions presented a frustrating problem for many years. It had long been known that they perform a so-called dance, their tails raised, the male grasping the female's chelicerae (jaws) in his own. Then, with tails lowered, the pair walk round and round, to and fro, back and forth, sometimes for hours at a time.

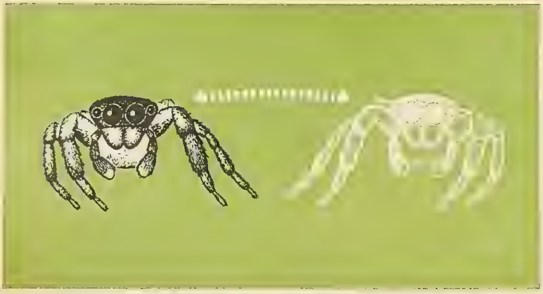
# Arachnids



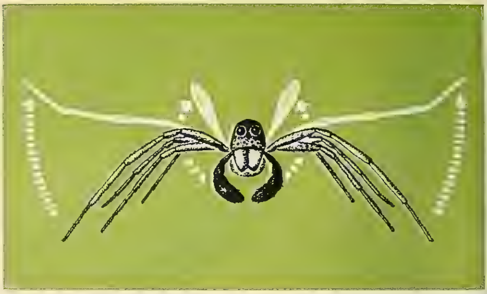
It has been reported that the actual mating always took place under the shelter of a stone and thus was virtually impossible to witness. The mystery was solved almost simultaneously by Dr. Anne Alexander of Grahamstown, South Africa, and several zoologists in India and Israel. The long walk seems to continue until the pair find themselves on ground that is smooth enough for their purpose, and perhaps it is the need for smoothness that causes the male to scrape the ground with his legs. Finally, he secretes a spermatophore and so controls the movements of the female that insemination can be effected. The resemblance between scorpions and pseudoscorpions is striking and significant in the consideration of the development of the courtship process.

The significance is increased by comparison with the behavior of members of the order Amblypygi, a group that is not so generally known. It contains about a hundred species, most of which have the flattened body that is associated with life in cracks and crevices. They have remarkably long, delicate, and sensitive forelegs and, like so many members of the Arachnida, their sense of touch is more acute than is their sense of vision. Anatomically, they might be described as spiders without silk, for they have a very similar bodily constitution. Their courtship follows a familiar routine. The male touches the female with his long legs, and although he does not grasp her, he subsequently goes through the same actions as do scorpions and pseudoscorpions. He deposits a transparent spermatophore and leads the female onto it. There is little evidence of any aggression before insemination, and none after it, when the male eats the empty spermatophore. It may be added that this process has also been seen in a member of the small order Tartaridae, and again a spermatophore is produced and used in the same way. The principle, which now may be considered as established, is that fertilization in Arachnida is achieved in most orders by the use of a spermatophore.

SPIDERS show a very different kind of behavior, which so strongly contrasts with that of scorpions and other arachnids that it makes a vital contribution to the whole study and understanding of courtship in general. It was first observed in detail by Dr. and Mrs. George Peckham of Milwaukee as long ago as 1889-90. Their observations were concerned with the jumping spiders, members of a highly specialized family that is characterized by large eyes, comparatively keen vision, and bright colors. The vivid descriptions written by these authors attracted, and continue to attract, the attention they deserve; their conclusion, which was written in terms of the theory of sexual selection, was not so fortunate. This initial work was followed by a number of more or less isolated descriptions of courtship by various writers, and more complete studies by T. H. Montgomery in Philadelphia, by U. Gerhardt in Germany, and by W. S. Bristowe and G. Locket in Britain.



**A jumping spider** displays in a most unusual attitude as it circles round the watching female with a lurching motion.



**During courtship,** wolf spider, *Lycosa lugubris,* stretches front legs sideways, raising and lowering alternate palpi.

To make clearer the sort of thing that these observers saw and described I choose, admittedly as but a single example, a species with which I have become familiar, and quote from my notes a description of the courtship of the wolf spider, *Lycosa lugubris.*

"The male appears to track the female with the help of sense-organs located on the legs; these react to the presence of a chemical substance on the ground, left by the female as she runs. When he reaches her, he gets in front of her and stops where she can see him. He straightens his legs, raising himself on six and holding those of the first pair horizontal and sideways. Now one palp is raised with a characteristic jerky movement until it is vertical; a moment later the second palp follows. This is the essential courting attitude, in which the legs are shot out sideways. This remarkable posture is retained for a few seconds only; then, while the front legs move or wave more obviously, the palpi drop into their usual positions. Again there is a momentary pause; then the moving of the legs stops, one palp is raised, then the other, and the pose is held once more.

"These actions are continued twenty, thirty, perhaps forty times. As a rule, both spiders remain quite stationary, about an inch apart. The female, quiescent, appears to be watching the male; I have never seen her attack him. Then, suddenly, the male stops, relaxes his legs so that his body drops to the ground, and now runs crabwise round the female, the tarsi of his forelegs in contact with her body or limbs as he circles. He seldom makes more than two circuits before he climbs on her, with her carapace beneath his sternum."

The general conclusion that followed from the observations of most of the biologists was that courtship was essentially an elaborate method of conveying to the female spider the information that a member of the opposite sex was in her neighborhood, with the corollary that he was not to be treated as an intruder—that is, promptly killed and eaten.

This puts the carefully considered opinion of serious zoologists in a short and, perhaps, rather superficial form, but it gives a fairly accurate impression of the conclusions to which most of them came. As long as the courtship of spiders alone is under consideration, the theory of sex-recognition can be reasonably maintained. When other arachnids are compared with them, different opinions are possible, and the courtship of spiders can be seen in a new light.

The accident of history that brought the courtship of spiders into prominence before it had been witnessed in the other orders is responsible for much of our failure to interpret the behavior in a way acceptable to all biologists. For this there are four reasons. First, the observer of spiders is, perhaps unfortunately, watching the phenomenon at the top of the arachnid evolutionary scale; courtship and mating are more easily witnessed among spiders, and their behavior differs very significantly from that of the other orders.

Second, interpretations have been disproportionately influenced by the belief that the female "always" kills and eats the male, who was therefore pictured as occupying a position in which he attempted, if only temporarily, the appeasement of his formidable partner. This cast a false light on the behavior of the male, and scientific writers tended to forget how many of the cases of slaughter took place in captivity, when the errant male was unable to escape; how few were the reports of this occurrence from observations in the field; and how sometimes reports told of the male eating the female. The truth is that there is not, and there never has been, any statistical support for the myth of the female always destroying the male. One may read the many careful descriptions of spider courtship without finding one that ends with the words, "The female then killed and ate the male." The belief has probably arisen because *Araneus diadematus*, the cross spider, which is the most commonly noticed of all spiders in the Northern Hemisphere, is one of the very few species that really behaves in this way.

Third, courtship displays are not confined to the arachnids, although they have developed it at least as fully as have insects, mollusks, or other invertebrates. The males of many of these groups indulge in essentially similar displays, and it follows that an explanation based wholly on the peculiarities of only a few spiders may not give a satisfactory interpretation of invertebrate courtship.

Fourth, the elaborate courtship of spiders must be the result of a long process of evolution. It cannot have been a consequence of a necessity for protecting the male, because, in the earliest times, before the courtship had become established, the males must inevitably have been killed. This is the essence of the popular theory of spider courtship—that it protects the males. Without it, there would have been no offspring, and the race would not have survived to develop the courtship we now see. This is but another example of the difficult fact that the first, small, chance variation would have no survival value on which natural selection would have been able to operate.

CLEARLY, it is necessary to examine the subject on a broader basis. We owe to the genius of Dr. Alexander the important hypothesis that courtship is a consequence of evolutionary adaptation to terrestrial life. The ancestors of the Arachnida were eurypterid-like creatures, living in water, and like most aquatic animals, they shed their millions of sperm near recently laid ova. In this case the only need is an association that will insure that the gametes of both sexes are liberated simultaneously.

Spiders have modified the conventional spermatophores. The males spin a sperm web on which the semen is deposited. From there it is picked up by the pedipalpi and retained in these limbs until the male has met and completed his courtship of a female. This method of sperm transference replaces the use of the spermatophore.

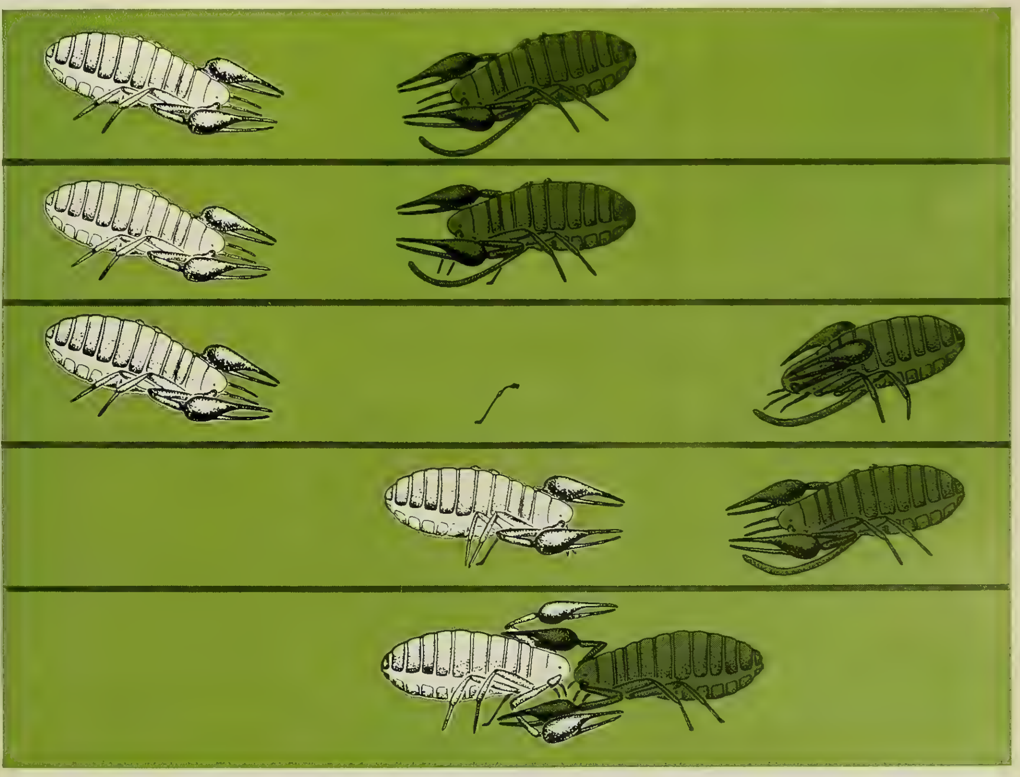
No spermatophore is produced by harvestmen (Opiliones), because the males possess an extensible intromittent organ in connection with the genital ducts and use it for direct injection of the sperm to the female. There is no courtship, and the reproductive habits in this order provide strong support for the hypothesis that relates courtship to a spermatophore.

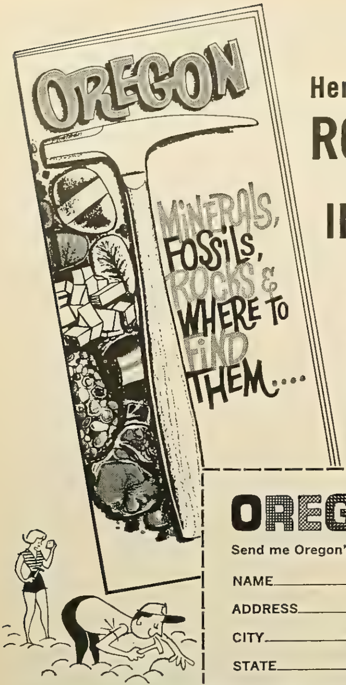
There remains, however, the original problem—the explanation of the existence of courtship in many of the arachnids. The first necessity is to understand the nature of the behavior. One may recall the valuable advice of Dr. E. S. Russell—that one must try to discover what an animal is driving at. The last two words may sound colloquial, but they should be retained as deliberately as they were used—to help us keep in mind the picture of an animal under the influence of a powerful urge, or drive. They might almost be replaced by an alternative—what the animal is being driven at.

A moment's consideration shows that courtship is a very typical example of instinctive behavior. It is a complex pattern of activity initiated in response to a particular situation in which both internal and external stimuli play their parts. It may well occur but once in the lifetime of an individual, yet it is performed successfully, and it leads, inevitably, to a result sometime in the future—the production of fertilized ova. Innate actions are well developed among arachnids, and in some cases careful study has broken down a long action into a series of reflexes, each of which appears as the appropriate response to a particular stimulus. The courtship of spiders and scorpions seems to be of this kind: the points of similarity mentioned above no doubt act as stimuli for the various and separate phases of the operation.

This leads to a discussion of the

**FALSE SCORPIONS approach each other, palpi outstretched. The male deposits a spermatophore in front of the female, at left, and animals separate. Female covers spermatophore and the male seizes and shakes her to complete the process.**





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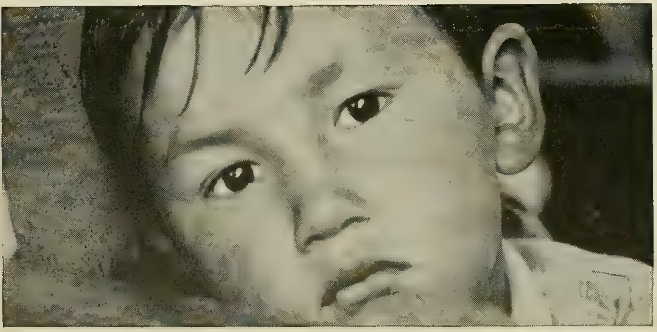

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purpose of courtship. The ultimate result of courtship is fertilization of the eggs, which occurs days or weeks later at the time of egg laying. The immediate result of courtship is delay in insemination, a delay that can be explained only if it has selective value or if it is inevitable.

That it is selective has already been considered. This was the earliest hypothesis; it was based on the habits of spiders and has been shown to be unsatisfactory as an explanation. It must therefore be assumed that the delay is inevitable, and it is reasonable to suppose that it is inevitable because of the complexity of the operation. The theory that courtship protects the male from a fierce female is tenable only where it is a secondary development among members of the most highly evolved orders.

THE complexity is due to several causes, the first of which is the need for efficient fertilization, which cannot be successfully achieved by land animals in the same way as by animals swimming in water, where a vast number of spermatozoa are liberated somewhere in the neighborhood of the ova. The device of the spermatophore overcomes this difficulty, which is not the only disadvantage accompanying terrestrial life. But it has brought with it problems of its own. These include the need for special stimuli to induce and guide the whole procedure of mating and, more important, the need for an exact placement of the female in order that the spermatophore may function at all. Together, these factors are sufficient to make the process that has been called courtship a lengthy operation of great precision. The vital fertilization of the ova may be delayed, but the delay is necessary. In life on the land, insemination is a matter of great precision, and some animals have evolved new organs, like that of the harvestmen mentioned or the aedeagus of beetles, to achieve it effectively. Others have adapted a limb to a new purpose, as have the spiders in making use of the pedipalp. Others again, like those described above, have produced the spermatophore. But a spermatophore cannot be used quickly; it requires accuracy and precision on the part of both sexes, and the activities that we call courtship are fundamentally to be regarded as the care given to the use of a complex and delicate device.

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## About the Authors

Eric Leshan, Nelson Samuels, Bruce Hobson, and Charles Coughlan, authors of "Sabino Grove Ecology Study," are students at Pacific High School in Palo Alto, California. One of the most unusual schools in the United States, Pacific High School opened in 1961 in a suite of downtown offices, and has moved seven times since then. This year, classes have been conducted in chinchilla huts on a forty-acre plot of land. Two new buildings are now under construction on the site. Classroom biology studies are supplemented by extensive field trips, such as the one described in this magazine. The students' most recent field trip, led by their teacher David Werner, was to observe gray whale breeding in the Gulf of California.

"African Pink-backed Pelican" was written by James Hancock, who is Aviation Manager for British Oil Company, London. He is a member of the British Ornithological Union, the British Trust for Ornithology, and the Royal Society for the Protection of Birds. Other interests include conservation, travel, and collecting old bird prints.

George C. Taylor, Jr., author of "Water, History, and the Indus Plain," is Chief, Foreign Hydrology Section, Water Resources Division, U.S. Geological Survey. In this capacity he oversees the Survey's foreign hydrologic investigations, which are under the auspices of the U.S. Agency for International Development and various United Nations agencies. Mr. Taylor joined the U.S.G.S. in 1937 and is the author of more than 30 articles and government reports on geologic and hydrologic subjects. He has worked extensively on water and mineral surveys in Central and South America and in the Far East, and recently was in charge of the Survey's program of ground-water investigations in New York and southern New England. While in India between 1950 and 1955 as a technical advisor in hydrogeology, Mr. Taylor became interested in the relationship between water resources and the cultural evolution of man in the Indian subcontinent.

Ralph J. Donahue, author of "Life Cycle of Seclusion," is a free-lance writer and nature photographer. His work has appeared in Natural History and in other leading publications.

Theodore Savory, author of "Courtship Behavior of Arachnids," is a director of Stafford House Tutorial College, Ltd., in London. He has authored many books and papers on the subject of arachnids, including *Arachnida*, recently published by Academic Press, London and New York.

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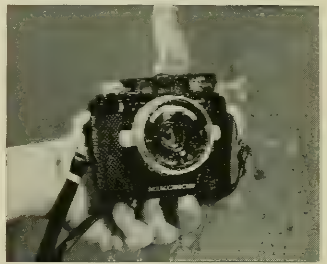

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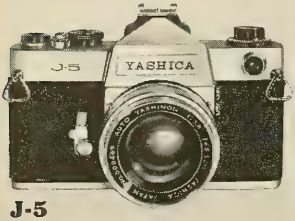

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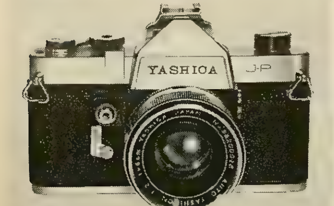

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# *The Kinishba pueblo ruins*

*By Jay Ellis Ransom*

Fifty miles by air northeast of the thriving copper city of Globe, Arizona, but not shown on maps of the state, lie the Kinishba ruins. Kinishba—the name as translated from Apache means brown house—is one of the largest and least-known prehistoric pueblo ruins in the Southwest. Straddling the two sides of the deep ravine of Cedar Creek, four miles west of Fort Apache and eight and a half miles southwest of Whiteriver (Bureau of Indian Affairs headquarters for the Fort Apache Indian Reservation), the ancient walled village housed between 1,500 and 2,000 members of the primitive Pueblo culture.

The enormous Kinishba pueblo represents an evolutionary period of one of the three main archeological patterns of prehistoric culture found in the Southwest, the Anasazi. (The other two patterns are the Mogollon-Mimbres, or Mountain, culture, and the Hohokam, or Desert, culture.) Because it existed on the plateaus of southern Utah and Colorado and northern New Mexico and Arizona, the Anasazi is also known as the Plateau culture.

The beginnings of the Anasazi pattern were in the Basket Maker period. The Basket Makers were Indians of Mongolian ancestry who emigrated from Asia across the Bering Strait, reaching the Southwest about A.D. 100. As the Basket Maker period evolved into what is known as the Modified Basket Maker period (A.D. 500 to 700), the architecture of living quarters also changed. Individual pit houses—poles and branches arranged domelike over a large pit and plastered with mud—were gradually replaced by multiroomed surface dwellings. These surface houses evolved, in turn, into the huge apartment buildings whose architectural splendor culminated in the Pueblo III, or Great Pueblo, period (A.D. 1100 to 1300). During this period the Kinishba Pueblo culture flourished.

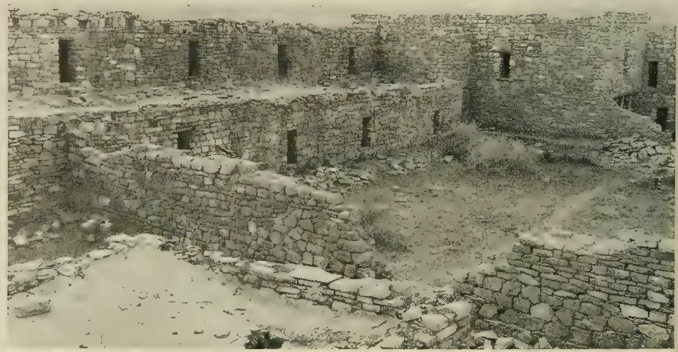
Spaniards who first arrived in the Southwest in 1540 may have heard of the huge Kinishba pueblo as one of the fabled Seven Cities of Cibola—the rumored cities of gold that lured early explorers to the region. However, the site was abandoned by the time of their arrival. One of the first white men to report on the ruins of Kinishba was Adolph F. Bandelier, in 1883. Thirteen years later, Walter Hough, subsequently Curator of Anthropology at the National Museum in Washington, D.C., made a preliminary survey of the mammoth ruin and was astounded by its dimensions.

Following Hough's return to Washington, the prehistoric site remained almost unknown and unmolested until 1931. Minor pilfering of artifacts, mostly by souvenir-hunting soldiers from Fort Apache, occurred along the edges of the arroyo and in a few ruined rooms. The real archeological treasures remained buried under the rubble and adobe that marked the passage of centuries.

## First Excavations

In 1931 the Arizona State Museum received permission from the Bureau of Indian Affairs, U.S. Department of the Interior, to excavate and investigate the ruins. At the same time, Dr. Byron Cummings of the University of Arizona received the approval of the Bureau to enlist a handful of students and begin preliminary excavations. In surveying the site, they named the heap of ruins on

Reconstructed interior court of pueblo shows entrances to individual apartments.



the east side of the arroyo Group I, because it was most accessible. After examining the entire site, Dr. Cummings found this section to be "representative of the period of highest development of prehistoric pueblo culture."

The now rebuilt portion measures 351 feet by 110 feet, an extremely compact labyrinth of one- or two-room apartments, the second and third stories of which had collapsed into the ground floor and courts. The mound of rubble contained a total of 210 separate apartments that were painstakingly pieced together by archeologists during the reconstruction period of the 1930's. Two-story dwellings were common, and here and there, like low, squat towers, a one-room third story rose above the massive sandstone walls of the outer houses. The west side ruins, Group II, have never been touched. Between the two sections of the pueblo lies a sheer-walled ravine one hundred feet deep, its watercourse—bone-dry except during cloudbursts—supporting scattered ponderosa pine trees from 100 to 300 years old. On all sides of the pueblo the flats stretch out to the low mountains.

By 1883, when Bandelier viewed them, the ruins consisted of eight separate mounds, parts of which had crumbled into the ravine. Originally somewhat shallower than it is today, this arroyo seems to have carried the all-important water that nourished both sides of the aboriginal housing project. A White Mountain Apache legend tells that the geologic faults in nearby Silver Butte and Big Mountain to the north, which supplied the life-giving water for Cedar Creek, were abruptly destroyed by a regional earthquake. Modern geologists say that this is quite possible, for although the water disappeared from the arroyo, it has continued to flow beneath the sandstone ledges to the present time. In fact, the twentieth-century excavators dug two shallow wells and obtained abundant, fresh, cool water.

## Apartment Complexes

Reconstruction of the Group I pueblo was accomplished during the middle 1930's by an Apache group in the Civilian Conservation Corps, following the detailed plans made by archeologists of the aboriginal floor systems. Originally, the pueblo was built of closely adjoining apartments according to a definite plan designed to provide maximum protection against hostile Indians. Tree ring dating has established that the great majority of the timbers hauled from the forested mountains were cut between the years A.D. 1150 and 1350, a period in which Navahos and Apaches were coming into the region. The entire sandstone pueblo had only three entrances or galleries through the massive walls, and these could be defended with a minimum of manpower assembled in the two large interior courts.

The outer rooms contained small, cramped, easily blocked-off doorways, and no windows, making the whole complex an unbreachable fortress during periods of siege when the upper walls and roof walkways were manned by the Kinishba defenders. Interior rooms, always dark except for the flickering light of a smoky pit fire, were entirely without natural illumination. These inner chambers could be entered through similar doorways, creating a chain of interlocking compartments.

Looking at the remains of the fire pits, one wonders how those primitive agriculturists stood the smoke and soot that must have pervaded the rooms, for there is no evidence of any type of air circulation or duct system. Only the looseness of the unmortared blocks of sandstone could have permitted enough oxygen to enter to allow a fire to burn and the occupants to breath comfortably.

In digging through the ruins, archeologists unearthed thousands of turquoise beads, coral found only along the Gulf of Mexico or present-day Baja California, and quartz crystal found locally in regional siliceous exposures.

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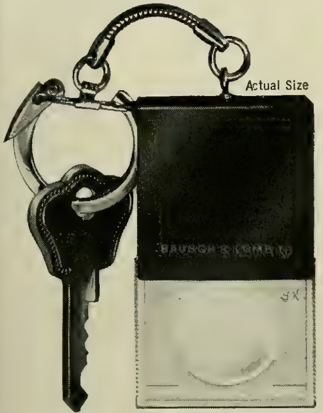

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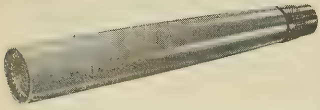

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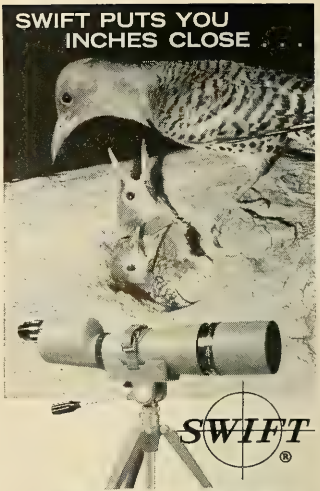
Also uncovered were great numbers of bracelets, rings, and pendants of every description, as well as ear jewels. Interestingly enough—and attesting to a belief in an afterlife, according to Dr. Cummings—one grave revealed a child's skeleton swathed in a necklace nearly six feet long, strung with 2,534 hand-polished turquoise beads. Among the beads shone eleven bright-red, pipestone (catlinite) inserts at carefully spaced intervals, showing perhaps that the child had lived for eleven winters. The effort that went into fashioning the extraordinary necklace is apparent to anyone who views it today in the Arizona State Museum.

### Mineral Pigments Used

SEVERAL important aboriginal trade routes seem to have coalesced at Kinishba, possibly the reason why this site was occupied for so long. Shells of clams, abalone, and screw shells (*Turritella*) must have come from great distances. Evidences of early trade and exchange are found in the surprising abundance of the smooth, shining "Indian money" shells (*Olivella*), which occur along the Pacific Coast and were gathered by the aboriginal tribesmen for ornamental use and as a medium of exchange, with values established according to the size of the shell. Mineral pigment paints of basic colors were found, still in their pots, amid the refuse on the floor of nearly every apartment. Some of these yellow or red ochers were used for personal adornment; others were used in decorating pottery. The varied mineral pigments were probably mined by primitive hand-digging methods in different parts of what are now the states of Arizona and New Mexico.

Iron oxides, mostly hematite, provided an imperishable bright red. Yellows came from pulverized limonite (another iron oxide); the greenish-yellow finish of Kinishba pottery may have come from uranium minerals, particularly carnotite. Malachite from the present-day copper region of Bisbee and Tombstone, well to the south, gave a strong green pigment, while blue came from grinding up azurite nodules. Kaolin, or china clay, gave the pottery a clean white sheen. Coal-black pigments came from manganese minerals commonly found throughout much of Arizona, especially in bold outcrops along what is now the crest of the Mogollon Rim west of Show Low. Another source was gilsonite, a brilliant, lustrous variety of asphalt found in Utah. Most of these paints must have been obtained by trade, and Kinishba was undoubtedly a phenomenally rich trading center for its time and place. From Kinishba artwork, for which these paints were used, we read the story of primitive nature worship. The gods of sun, rain, thunder, and lightning had



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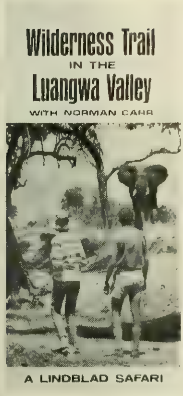

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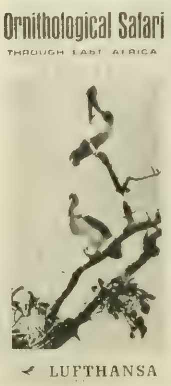

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to be placated before a bountiful harvest of corn, squash, and wild grains could be achieved. Almost everything that the Kinishba craftsmen made they decorated, and while many of the designs reveal influences from other regions—New Mexico, northern Arizona, northern Mexico, and California—there is no evidence of copying. The designs, for the most part, are distinctive and original.

## Kinishba Society Ends

Despite the ingenuity and creativity of its inhabitants, however, the Kinishba pueblo could not maintain itself. Prolonged drought, earthquake destruction, and the growing pressure of invading Navaho and Apache tribes made existence impossible for the Kinishba peoples, and they disappeared. (The Pueblo Indians of northern Arizona may represent their descendants.) Since there is no evidence that they were destroyed, they may have moved to a more hospitable area of greater rainfall and, perhaps, been absorbed by the indigenous populations. In any event, the mystery of what happened is as great today as when Walter Hough first saw the enormous "Brown House" in 1896.

Because of the wealth of archeological materials found, the Bureau of Indian Affairs sponsored construction, near the ruins, of a museum designed to house exhibits of artifacts sorted according to era. In addition to the main display room, the museum structure—built as much as possible in accordance with the technique of rockwork employed by the pueblo builders, but strengthened with mortar—was fitted out with laboratories, storerooms, and quarters for a full-time custodian and his family. A 140-foot well was drilled to supply water for a 40,000-gallon storage tank. This water was then piped throughout the museum. Thus, in the early 1940's, everything was set for fulfillment of Dr. Cummings' plan to develop an enduring education center that would benefit students, tourists, and Apaches alike.

The plan was never realized, perhaps because World War II prevented tourist travel during the 1940's or because the region—easily accessible by paved highway today but only by dirt road twenty years ago—was too remote. At any rate, few travelers visited the museum, and the astonishingly complete reconstruction of the great Brown House. The whole project languished. Civilian Conservation Corps funds ran out, as did those available from the Bureau of Indian Affairs. In 1954 the exhibits were removed to the Arizona State Museum, and the project was finally abandoned.

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Mr. Ransom's latest book, *A Range Guide to Mines and Minerals*, was published in 1964 by Harper & Row.

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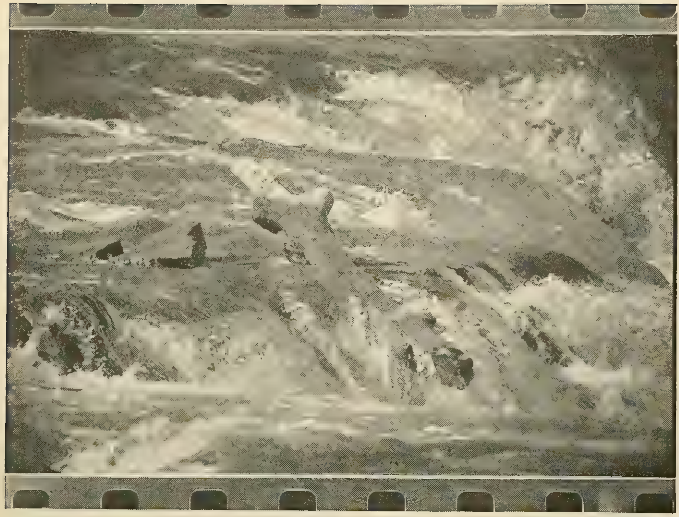

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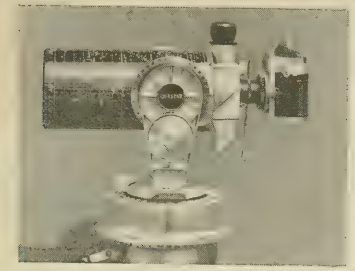

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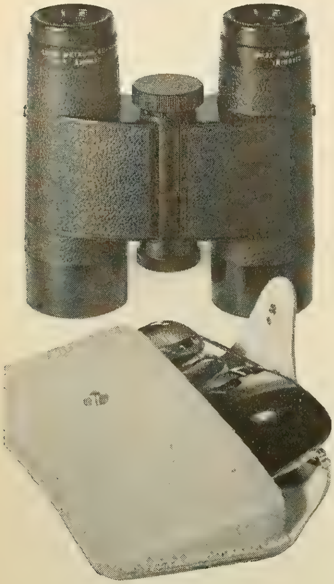

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# Steps to new astronomy

By George A. Rothrock

It is with some trepidation that the historian ventures into so technical a subject as the birth of the new astronomy. However, some of the points raised by Colin A. Ronan's interesting article on Tycho Brahe in the January, 1965, issue of NATURAL HISTORY lie more in the province of the historian than of the astronomer, and it is to be hoped that more dialogue across the line that so often separates humanists from scientists might be stimulating and useful to both. One of the most provocative aspects of the scientific revolution has generally been the resistance to the new astronomy as it developed in the latter sixteenth and the seventeenth century. The best efforts to clarify this problem have thus far been confined to rather technical works not readily accessible to the interested layman. Thus the following observations, while offering little that is truly original, may have some use.

In the first place, it is not strictly correct to conceive of the sixteenth-century debate in astronomy as a contest between two geometries of the heavens—Ptolemy's earth-centered (geocentric) and Copernicus' sun-centered (heliocentric) theories. While Copernicus was essentially a mathematician and was primarily concerned with a conceptualization of heavenly geometry that would improve predictive accuracy, the Ptolemaic system was inextricably bound up in at least two far vaster structures that made any attacks upon it suspect.

## Aristotle's Universe

The classical tradition that formed the basis of Western scientific concepts was much broader than is usually suggested by references to Ptolemy. The problems become really meaningful only when set against the total perspective of Aristotelian natural philosophy. For example, the famous crystalline spheres were implicit in Aristotelian rather than Ptolemaic thought and were essential to explain why the planets revolved. Similarly, the earth-centered universe was the foundation of a whole system of mechanics. Thus any attack upon traditional astronomy had to face not only the opposition of astronomers' conservative attachment to accepted theory but also had to provide answers, or at least the possibility of rational answers, to a whole series of questions in mechanics and natural philosophy.

The universe of Aristotle was an integrated and self-sufficient entity. It was infused with inherent "qualities" and "properties" that rendered it explicable. Some of these concepts are still extant in popular phrases; how often one hears teleological comments such as: "the sun is trying to shine" or "nature abhors a vacuum." These notions were quite real in ancient science, and their implications were vast. For instance, it was a property of a sphere to revolve about its axis, a motion natural to its form. Thus, if a planet were set into the wall of a sphere with the earth somewhere near the center, the apparent revolution of the planet about the earth was readily explained. Without the sphere it would have been necessary to postulate some outside force acting upon the planet to move it. As it was generally accepted that the application of constant force resulted in constant velocity (not a constant acceleration thereof), the postulate would have required not simply an initial force at some point in the past to begin the motion, but a continuing force to maintain it. Moreover, Aristotle made a distinction between earthly and heavenly substance. Aware of the problem of friction, he could, nonetheless, ignore it in the movement of heavenly spheres, simply establishing them as frictionless by definition. The physical characteristics of earthly substance only applied to material inside the orbit of the moon, the sublunary regions. Beyond the moon were heavenly substances, immutable and obeying different laws. If the earth were displaced from the center of the system to one of the spheres, then celestial mechanics would have had to admit the problems of friction and earth-substance mechanics.

## The Four Elements

The implications of the earth-centered universe reached far beyond astronomical physics, however. Aristotelian natural philisophy assumed that the world was composed of four basic elements: earth, air, fire, and water. A property of each of these elements was "natural motion" in the direction of its "region," or natural position of rest. At the center of the universe lay the region of earth. In an enveloping layer came next the region of water. Above the regions of earth and water lay those of air and fire. When these elements were released from entrapment in mixtures, they had a natural motion in the direction of their own regions, a motion that was rectilinear toward or away from the cen-

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ter of the universe. If the sun were to be allowed to replace the earth at the center of the universe, then suddenly movement on the earth would become inexplicable. Why would a "heavy" object, composed primarily of earth and water, move to the surface of the earth when dropped rather than fly off toward the sun?

The whole structure of Aristotelian physics was so tightly interconnected that a challenger of one facet of the structure could easily find himself entangled in a quarrel over the whole. While Aristotle was wrong about many things, his towering genius was capable of vaulting conceptualizations that are still breath-taking, and few minds would be able to challenge the full scope of his work. Aristotle's strength was also his weakness, however. As has been pointed out, from the very interrelatedness of the Aristotelian world system it followed that if dogged persistence could discredit a part, the whole must stand suspect.

## Astronomy and the Church

THE earth-centered universe was also intertwined into another concept of the nature of the universe— Christianity. It is inane to assume that the medieval church was inflexibly and dogmatically opposed to scientific investigation. Such an early scientific light as Roger Bacon was himself a churchman. And most savants of the Middle Ages assumed that all knowledge, empirical or revealed, was ultimately reconcilable. For example, the Church early came to terms with astrology. A very popular study, astrology seemed to threaten free will and thus the foundation of medieval Christian doctrine. How could a man be personally responsible for choosing God's way and renouncing evil if, in fact, planetary conjunctions determined earthly affairs? The impasse was, however, more apparent than real. Churchmen held that it was quite possible that physical nature was influenced by astrological events, but they asserted that affairs of a non-material nature, questions of the soul, could not be so influenced, and man remained responsible for his choices. The medieval Christian could turn to astrology to determine whether it might be propitious to plant a field or to start a war, but he still had to rely upon doctrine and his conscience to save his soul. Until the great sixteenth- and seventeenth-century controversies, the Church rarely adopted official positions on scientific questions. Churchmen and scientific investigators (who were often the same, since the church supported the universities) assumed the unity of knowledge and remained convinced that contradictions were apparent, not real.

Nonetheless, an endorsement of geocentrism and, also, a condemnation of heliocentrism were implicit in broad Christian concepts and were supported

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by popular theology. A literal reading of the Old Testament also tended to support geocentrism, and the new Protestant groups of the sixteenth century condemned Copernican ideas from the outset. Christians generally proceeded from the assumption that the universe existed primarily as a setting for the divine drama of conflict between good and evil, and much followed logically. Man was the protagonist of the drama, attracted by God on the one hand and drawn by the weakness, the fatal flaw, of his own sin toward evil on the other. In such perspective it appeared only natural that man's own domain, earth, should be set center stage, with the other bodies of the heavens forming a sort of backdrop. Even the physical nature of the heavens seemed to reflect this pattern. Brightest of the heavenly bodies were the stars; set in the outermost sphere, nearest God's heaven, they glowed with the brilliant white of purity. Farther removed from the source of purity, the planets gleamed less brightly. And of course it was readily apparent that the dross earth, blighted by the corruption of evil, glowed not at all. Such notions may appear silly, but they accorded with observable sense experience and reinforced suprarational concepts of what the world should be like—an unbeatable combination in a society not yet influenced by Cartesian skepticism. The rather mystical world view of the Middle Ages is most clearly summarized in all of its literalism in Dante's *Divine Comedy*. No one following the poet's beautiful portrayal of the world God made can be unmoved by the perfect accord of beauty, sense perception, and Higher Truth.

### Tradition Challenged

Thus, attempts to overthrow the traditional astronomy faced a formidable array of opposition. Researchers interested in mechanics, with no particular concern for celestial mechanics, would have found their whole work undercut by any displacement of the earth. Natural philosophers concerned with causation in the universe would have faced the necessity of starting afresh. Theologians, if not actually facing doctrinal problems, would have been sorely troubled to explain why God would set his drama in the wings, as it were. And one cannot overlook the enormous psychological shock to human egocentrism implicit in any assertion that, rather than being a central figure set center stage, man was in fact a mite clinging to a ball of dirt spinning at fantastic speeds through the universe. To challenge successfully so much entrenched opposition, a new system would have to offer real advantages—greater precision, more accuracy of prediction, implications of a fruitful new physics. Certainly, pious platitudes to the effect that it was equally conceivable that God would set the sun, giver of light and warmth, in the center of His creation would not be sufficient to balance the new problems created.

On the other hand, Aristotelian theory faced some serious troubles by the sixteenth century, troubles only partly related to the challenge voiced by Copernicus. In the first place, Aristotelian concepts, as rendered into calculable geometry by Ptolemy, were simply not accurate. Precision of prediction continued to be elusive. Adjustments of the system helped to rectify the situation slightly but at the price of enormous complexity. Obviously any attempt to explain elliptical motion, as seen from a moving viewpoint, in terms of circular motion, as seen from a stationary viewpoint, could not be easy. But two assumptions were fundamental to predictive astronomy; first, that the form of motion was regular, and second, that the speed of motion was regular, if not constant. Without these assumptions one would have to presume the universe erratic and study of it fruitless, hence the endeavor to modify Ptolemaic and Aris-

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totelian concepts to achieve this necessary regularity.

The device employed in this effort of modification was the epicycle, which can be expressed fairly simply in Ptolemaic geometry. It was based upon an assumption that a planet did not actually follow the course of its orbit, but rather revolved on a short radius about a point that followed the orbit assigned to that particular planet. Anyone can quite readily create a model of the motion thus conceived. A circle should be drawn on a flat surface and a small plate set upon it so that its center is upon the circumference of the circle. Then a dot should be marked upon the edge of the plate to indicate the planet. If the plate is then rotated about its own center while at the same time being advanced along the drawn circle, the apparent motion of a planet viewed from the earth will be approximated for a viewer in the center of the circle. Where the advance of the dot around the rim of the plate coincides with the direction of the plate around the circle, the dot will appear to accelerate. Where the rotation of the plate causes the dot to fall toward and across the line, it will appear to decelerate. And as the rotation of the plate carries the dot in a direction contrary to the motion of the plate along the circle, the dot will, depending on the relative speeds of rotation and revolution, appear to halt or even to assume a retrograde movement.

As experience demonstrated the inadequacy of a simple Ptolemaic system for making predictions, more epicycles were introduced. Moreover, to make his system work at all, Ptolemy had found it necessary to displace the focus of his circles to a point outside the earth. (This was assumed to be a mathematical contrivance without implications for Aristotelian physics.) Thus, calculating a predicted position for a planet necessitated: (1) a determination of the planet's position on the epicycle; (2) a determination of the epicycle's position on the orbit; and (3) a consultation of tables to determine the rates of rotation and revolution of the epicycle. This would establish predicted position relative to the focal point; it was then necessary to recompute to adjust for the earth's displacement from the focal point. Obviously the opportunities for error were legion, and predictions were sometimes wildly inaccurate. Inaccuracy and excessive complexity invited criticism and reform. Copernicus' solution—to challenge the concept—was only one possible approach.

## Brahe's Proofs

In addition to these internal problems, Aristotle's natural philosophy was also confuted by external contradictions. The careful proofs of Brahe that the new star and the comet of 1572 and 1577, respectively, were changes in the heavens beyond the moon made Aristotle's distinctions of earthly and heavenly matter—the latter immutable—untenable. These proofs did not automatically discredit the whole of Aristotle—heavenly matter could be mutable and still different and frictionless—but certainly they did further undercut his reputation for infallibility.

In the context of these remarks it is also important to note the difficulty of challenging either the theory or the observations of traditional astronomy because of the woeful inadequacy of instrumentation. In his own day Brahe was famous, and justly so, for designing more accurate instruments, but even these fell far short of modern standards of exactitude. One of the chief objections made to Copernican heliocentrism was that if the earth moved, some shift in the positions of the fixed stars—parallax—should have been observable. In fact, such movement does occur but the distances involved are so great that it is minute, and no instruments of the sixteenth century were able to measure it.

What, then, did the critics offer to replace the system they found inadequate? For what gains did they advocate scrapping the foundation on which so many understandings of the world—physical, spiritual, and moral—were based? Copernicus was not an observer. For the most part he accepted the traditional body of observational data with all its errors, and he never challenged circular orbits. Consequently, despite the heliocentricity of his system, he could not make the planets behave much more rationally than Ptolemy. He reduced the number of epicycles, but he could not eliminate them. He offered a system that would overturn traditional astronomy, but the only advantages he could really claim for it were a degree of simplification and a degree of improvement in predictive accuracy. Brahe, too, failed to find the key to measurable regularity in the heavens with a simple heliocentric system. It was his student, Kepler, who finally abandoned the hallowed circles and, after some unsuccessful experiments with ovals, hit upon the ellipse as a form that was calculable and eliminated many of the discrepancies of theory and observable planetary behavior.

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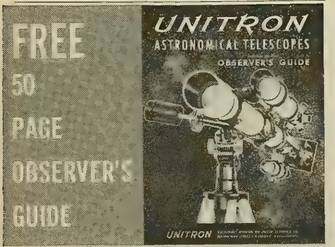
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Dr. Rothrock, who is an Associate Professor of History, University of Alberta, Edmonton, specializes in 16th- and 17th-century France.

Thus the astronomical debate was no simple conflict between truth and error, between two celestial geometries, between "modern experimentalism" and "medieval obscurantism." Far more than geometry was involved in any displacement of the earth from a central position in the universe, and the first great critics, Copernicus and Brahe, simply could not prove, as against establishing a reasonable presumption, that Ptolemy and Aristotle were wrong. Yet Copernicus and Brahe were massively important. Their significance lies at the root of the work for which each was most famous. Despite the fact that he was not an observer, despite his trusting acceptance of traditional data and circular orbits, Copernicus represents an important step toward modern science in his determination to cling doggedly to a single question. He sought a hypothesis that most simply and with the fewest contradictions would organize known data into a comprehensible and experimentally verifiable system, and he refused to concern himself with, or diffuse his energies into, ancillary problems posed in mechanics, morals, or theology. He had no desire to be a new Aristotle; apparently he wanted to be a good astronomical mathematician.

In the same manner, Brahe's significance lay in his singleness of purpose. He was determined to compile an accurate body of observational data that might resolve the contradictions of both Ptolemy and Copernicus. In Johannes Kepler the basic work came to fruition. Heliocentrism and mathematical analysis based upon relatively precise observational data produced Kepler's laws of planetary motion, embodying both regularity and simplicity. Much remained to be done, but despite the array of accepted opinion and vested interest that opposed the new astronomy, heliocentrism was set on an unshakable base.

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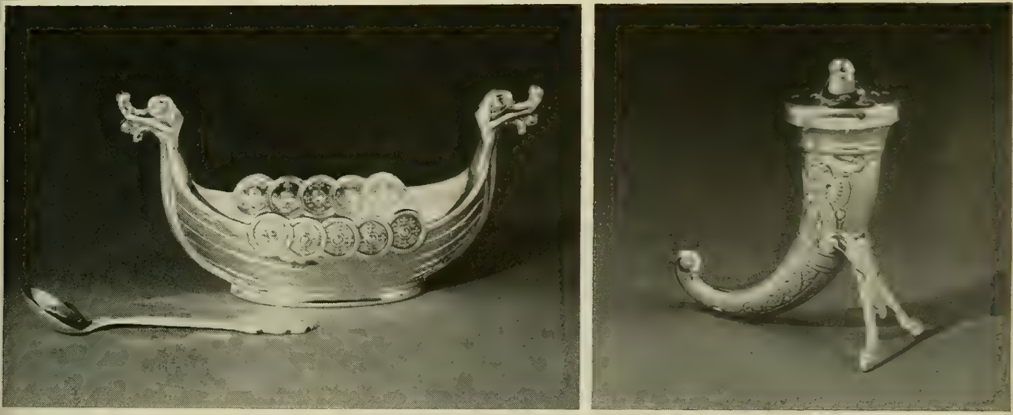

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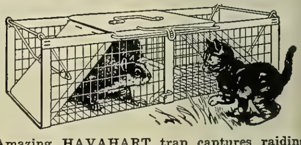

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[illegible] station on the sunny side of [illegible]

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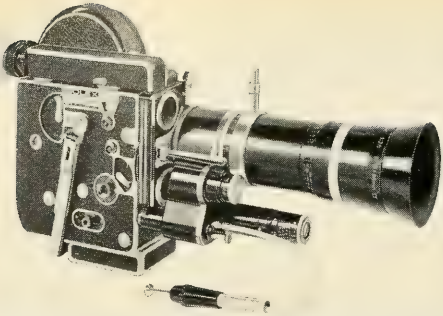
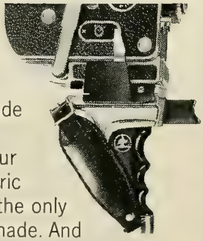


# The money camera puts its reputation on the line every time. Don't you?



When it only happens once. And there's no going back. That's the time for Bolex 16: "the money camera." Because "the money camera" is a pro. Like you. And is made to come through in the clutch.

Take the Bolex H-16 Rex with our Vario-Switar 86EE automatic electric eye zoom lens (shown above). It's the only 16mm electric eye zoom camera made. And for press and TV commercial production there's nothing like it. We realize you can read a light meter and change f/stops. But say you're shooting a parade. And just as you're zooming in on some dignitary the sun goes in. What do you do—take a new reading and readjust? Not with the 86EE. You just keep shooting automatically. Anything from wide angle to telephoto. And automatic loading and spool ejection speedup loading, too.

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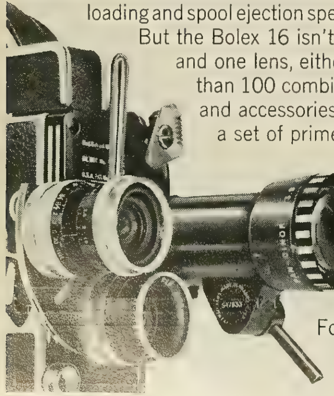

So now you know the story of the Bolex 16. It's versatile, rugged, dependable. Now you know why we call it "the money camera." And you know why for press coverage and TV commercial production you should put your money on it.

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For further information on the Bolex 16 or our free catalog, write: Paillard Incorporated, 1900 Lower Road, Linden, N.J. 07036.

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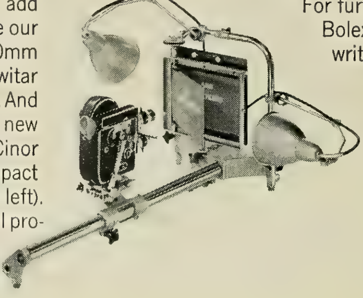
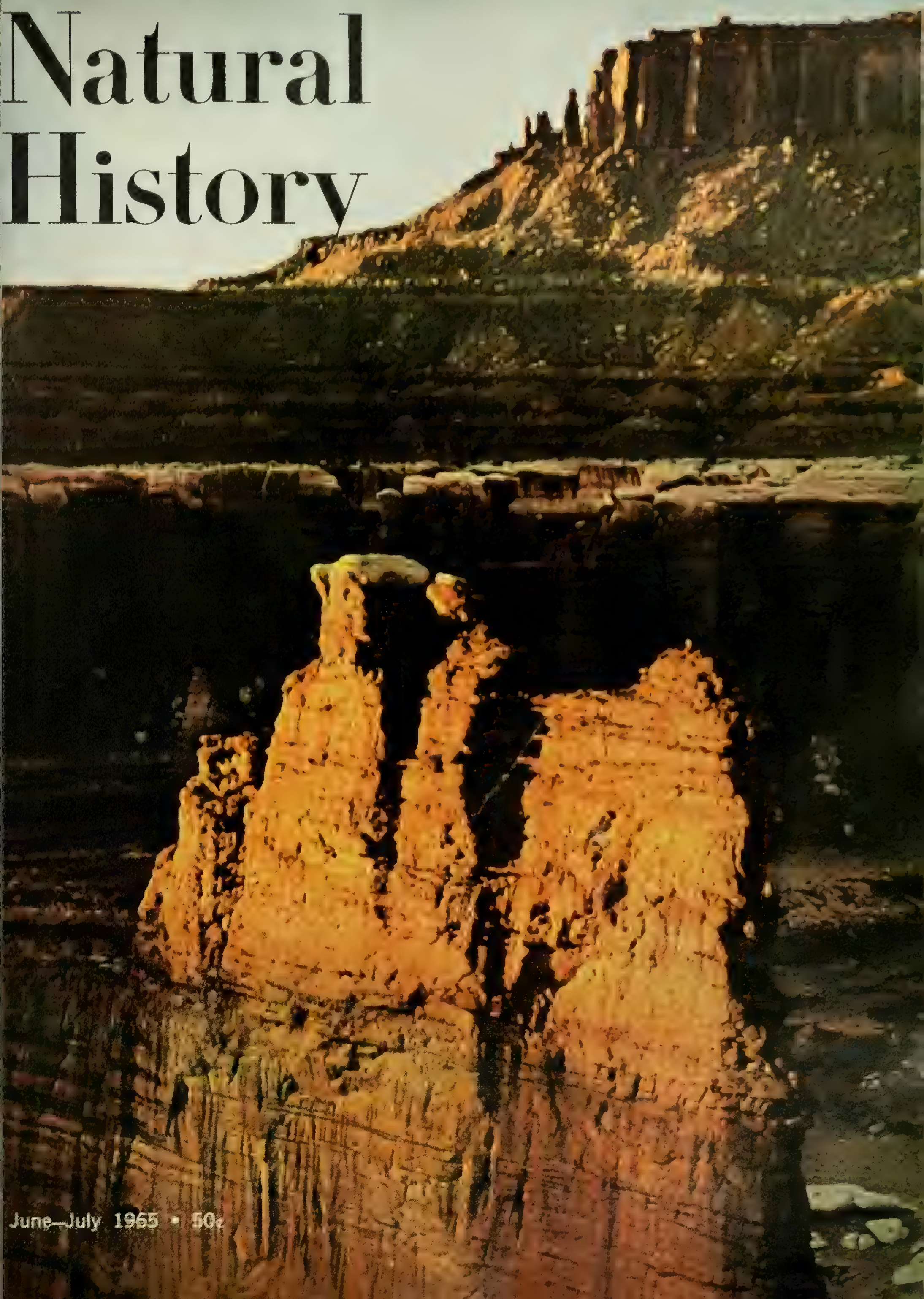


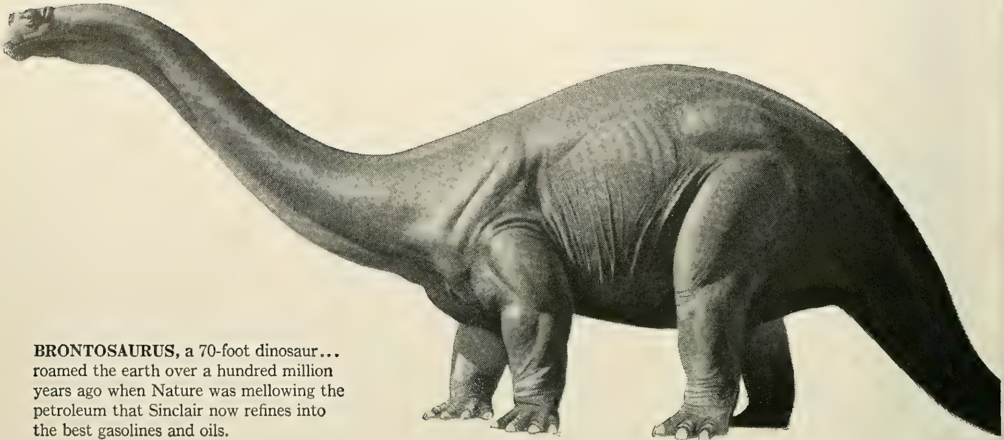
# Natural History



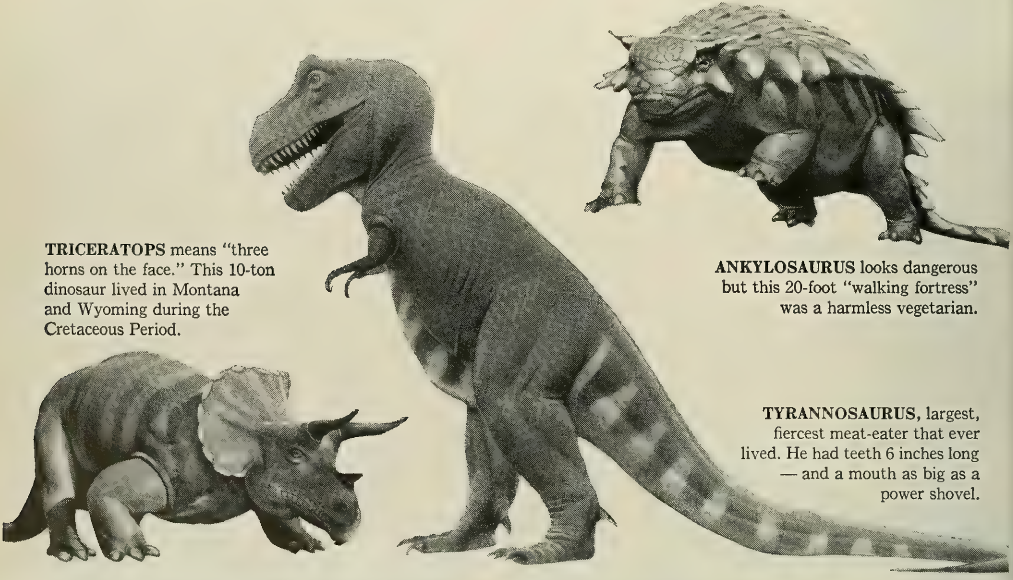
June–July 1965 • 50¢

# Which of these 4 dinosaurs is your favorite?

(See them in Sinclair Dinoland at the World's Fair)



**BRONTOSAURUS,** a 70-foot dinosaur... roamed the earth over a hundred million years ago when Nature was mellowing the petroleum that Sinclair now refines into the best gasolines and oils.



**TRICERATOPS** means "three horns on the face." This 10-ton dinosaur lived in Montana and Wyoming during the Cretaceous Period.

**ANKYLOSAURUS** looks dangerous but this 20-foot "walking fortress" was a harmless vegetarian.

**TYRANNOSAURUS,** largest, fiercest meat-eater that ever lived. He had teeth 6 inches long — and a mouth as big as a power shovel.

We know *our* favorite. It's *Brontosaurus*...Sinclair's famous trademark. Millions saw him and 8 other life-sized dinosaurs in Sinclair Dinoland at the New York World's Fair. We hope you and your family come to the Fair this summer . . . See this exciting and scientific re-creation of the prehistoric world.

For a more pleasant trip, we'll be happy to plan your route through interesting and historic sections of the country. For example, the *Dixieland Trail* covers 5 southern states, takes you over 6000-foot peaks to secluded ocean beaches, historic forts, battlegrounds, elegant antebellum homes, many other landmarks of the old South.

**This Sinclair service is free.** Write Sinclair Tour Bureau, 600 Fifth Avenue, New York, N. Y. 10020. Tell us the areas you want to visit in U. S., Canada or Mexico.

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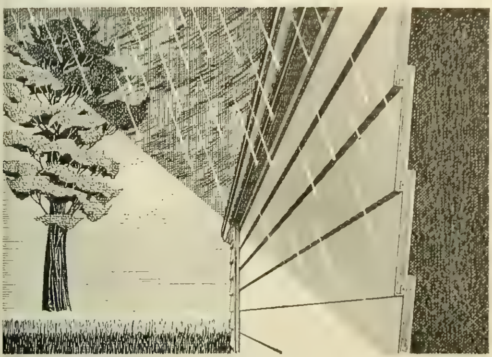
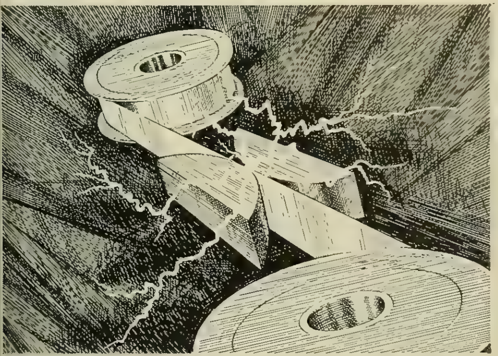
# WHAT'S GOING ON HERE?



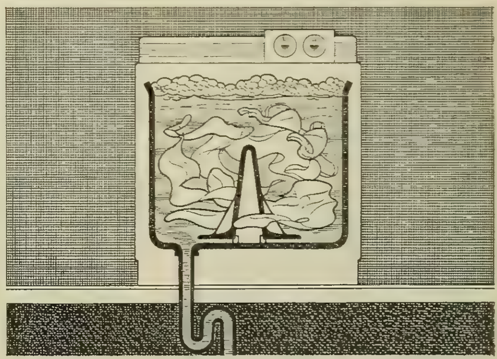
**New Monsanto solid vinyl siding** won't chip, peel, blister, rot or wear thin. Its lifetime beauty comes from clear-through color. It doesn't need paint, keeps its brand-new luster year after year after year. Rain washes it clean and bright. A product of Monsanto research.

**Goodbye Asian flu** when a Monsanto microbe-killer called Santophen® 1 goes to work. It makes potent disinfectants of ordinary soaps and detergents . . . kills viruses that cause Asian flu, staph and tuberculosis. Cleaners and disinfectants based on Santophen 1 are used in schools, restaurants, hospitals and homes.



**Electricity on tape** now provides a new source of power. Developed by Monsanto Research Corporation, the tape battery* looks like a tape recorder. One side of a special tape is coated with electro-chemical "fuel," the other side with an oxidizer. As the tape passes between current collectors, electricity is drawn off instantly.

**For the National Aeronautics and Space Administration (NASA).*



**Monsanto's new "soft" detergent** base helps solve the foaming problem of detergent wastes . . . teams up with nature to destroy itself more rapidly by bacterial action. This important development came after seven years of intensive research . . . another example of how Monsanto moves on many fronts to serve you.

What's going on here? Plenty! With our 4,000 scientists churning up many new discoveries . . . with our salesmen scouting the world for market opportunities . . . with new uses popping up for our 250 products that didn't even exist before the 1960's . . . you can understand why we're literally flooded with new ideas. And that's just fine. Innovation keeps Monsanto on the move . . . to serve people like you. Monsanto, St. Louis, Missouri 63166.

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# Natural History

Incorporating Nature Magazine

*THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY*

Vol. LXXIV JUNE-JULY 1965 No. 6

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COVER: This breath-taking view is part of the nation's newest national park—Canyonlands—located in southeastern Utah, and straddling the confluence of the Green and Colorado rivers. In the background is the red sandstone of Grand River Point, some 6,200 feet high, located on a giant formation called Island in the Sky. Secretary of the Interior Stewart L. Udall, whose deep interest in Canyonlands helped spur legislation that incorporated this great land treasure into the National Park System, discusses his philosophy of conservation needs for modern man, with Canyonlands as an example. His article begins on page 32.

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| | Charm | Pendant | Earrings |
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| **Silver** | $17.89 | $19.89 | $27.79 |
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## PRE-COLUMBIAN DISCOVERY!

*over 2000 Years Old . . .*

busts & torsos from the Valley of Mexico's primitive Indian culture dating from before the Birth of Christ. Masterful artisans crafted these mysterious clay figurines, early examples of *pestellaje* technique (applied features) used in pre-classic American art. Approx. 1¾" high, attractively mounted on walnut base, *these ancient creations make fascinating museum-like displays for home or office.* Unique gift idea!

| | |
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| SELECT Specimen, mounted | $12.75 |
| Average Specimen, mounted | $ 9.75 |

## BRONZE AGE ARROWHEADS . . . *

Excavated from famous archaeological sites in "AMLASH" (near the mts. of LURISTAN!) Bronze Arrows date from 15th-8th Cent. B. C. & exhibit rich malachite green patina! *Each arrow a magnificent display piece . . . unique*

| | |
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| SELECT Arrowhead 3"-5" | $6.50 |
| Average Arrowhead 2"-3" | $4.50 |

FREE: Plastic display stand for arrow

*SEE—"The Illustrated London News", May 5, 1962, P. 699-701

## EXOTIC COINS

. . . from the "sinister" gaming dens of Siam's 18th and 19th Centuries! Used as a means of exchange, these attractively fashioned porcelain coins reflect the simple beauty inherent in Oriental art. Now these very coins crafted with sterling silver make exotic all occasion jewelry. In addition, you can frame them creating a unique wall decoration.

| | |
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| Siamese gambling porcelain coin, each | $1.75 |
| Collection of 6 different design coins | $7.90 |

| —HER JEWELRY— | | —HIS JEWELRY— | |
|---|---|---|---|
| **CHAIN & PENDANT** | **CHARM** | **TIE TACK** | **CUFF LINKS** |
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MATCHING EARRINGS

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*(from 18th-19th Cent. Siam)*

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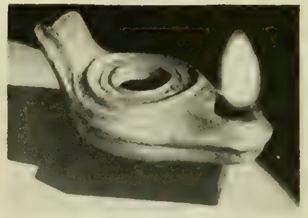

## ANCIENT *HANDLE* LAMP

*Light the dim past . . .*

brighten your home or office decor! Actually excavated in Ancient Palestine this collection of *Handle* lamps dates from the 4th to 7th centuries A.D. You can rekindle lamp's ancient glow with wick and vegetable oil. Lamp symbolizes knowledge! *Will stimulate thought-provoking conversation. A superb all-occasion gift to be admired forever!* Lamp on hardwood base with parchment certificate of authenticity $22.

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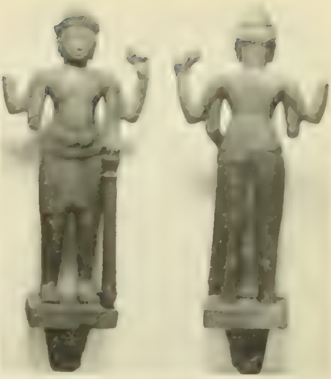
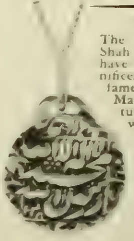


## VISHNU

*Stone, 30" high*
*SITE: Angkor Wat, Cambodia*
*DATE: 10th-12th Century, Khmer*

Vishnu (Blue God)—Preserver of energy. Has four hands in which he holds a shell (shankha), a quoit (chakra), a club and a lotus flower. **$19,500.**



## COIN OF INDIA

The heavy silver coins of the Shah Jahan Empire (1632-1653) have been transformed into magnificent handcrafted jewelry. This famed Indian ruler built the Taj Mahal, the worlds most sumptuous memorial to a beloved wife. Coins of Shah Jahan, historically symbolizing his immortal love for the Empress Mahal, are now available as regal charms, pendants & cufflinks. *A gift truly expressing eternal love!*

| | |
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| Silver coin cufflinks | $28.50 |

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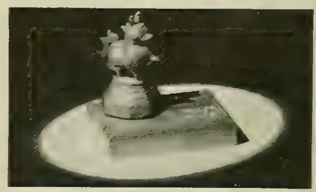
animal fossil (blastoid) frequently called "Sea Bud," actually lived over 230 million years ago. Nature's design, five vents surround center giving the blastoid a futuristic look. Now, this fantastic fossil has been crafted with sterling silver, creating unique jewelry . . . while remaining an alluring scientific curio! *Give as intriguing gift from "The Dawn of Life on Earth"!*

| PENDANT | CHARM | EARRINGS |
|---|---|---|
| $6.95 | $4.95 | $9.95 |



## *Miniature* OPIUM WEIGHTS

The sale of opium in 17th-19th Cent. Siam & Burma was state controlled. Used to weigh opium, these stylized bronze lions, ducks & elephants, handsomely mounted on walnut bases (or lucite) are approx. ½" to 1" high, weighing approx. 2/5 to 1 oz. Useful & unique as paperweights, they make an exotic addition to all collections . . . *a most intriguing gift from the Orient!*

| | |
|---|---|
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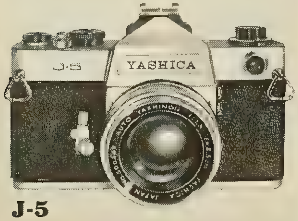

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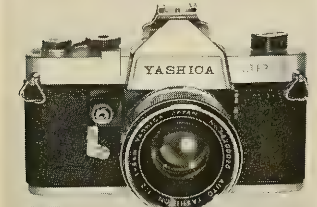

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# Of interest to birders

### By Eugene Eisenmann

Birds of the World, by Hans Hvass. *E. P. Dutton & Co., $4.95; 210 pp., illus.* The Birds of Arizona, by Allan Phillips, Joe Marshall, and Gale Monson. *University of Arizona Press, $15.00; 212 pp., illus.* The Oxford Book of Birds, by Bruce Campbell and Donald Watson. *Oxford University Press, $8.00; 207 pp., illus.* Song and Garden Birds of North America, edited by Alexander Wetmore. *National Geographic Society, $11.95; 400 pp., illus.*

These well-illustrated books reflect the burgeoning public interest in birds. Presidents and princes, proletarians and schoolboys find some special satisfaction in "birding." I suspect that for many people, this is connected with a nostalgia for the country, where life is simpler, less restrained, and less crowded. Then, too, birds, unlike many other animals, are rarely harmful to human interests, and because most of them are diurnal, as is man, they prove to be easy subjects for observation and study.

The first work to be considered here is *Birds of the World,* written by Hans Hvass and illustrated by Wilhelm Eigener. This is an unpretentious little book that pictures in color over a thousand species—about an eighth of the world's avifauna. It is a translation from the Danish, and emphasizes European species and others that are spectacular or popular in aviculture and zoos. Tropical birds are relatively not as well covered (as is true in many such works), although they comprise at least two-thirds of the bird species of the world. However, almost all families are represented by an illustration of at least one species. An occasional drawing is not accurate, the color printing leaves something to be desired, and there are a few caption errors, but the book serves its purpose of giving a picture of the variety of the world's avifauna. The text is brief—little more than a commentary on the pictures—and gives the scientific name, the English name (often not the current one in America), an indication of range, and sometimes a sentence or two on behavior. Considering its modest price and convenient format, the book can be recommended for those who wish to have a popular, inexpensive, and generalized glimpse of birds relatively unfamiliar in the United States.

The first full account of the avifauna of Arizona is now available. *The Birds of Arizona,* by Allan Phillips, Joe Marshall, and Gale Monson, is more elaborate and original than the usual state bird book, for in addition to giving the habitat preferences, distribution, and migration data (often illuminated by diagrammatic maps), there are many comments on classification. Thirteen water colors of birds, chiefly by G. M. Sutton, a large number of color photographs by Eliot Porter, and some fine habitat photographs adorn the volume. Most works of collaboration tend to be stylistically bland, but the authors of this one pepper it with outspoken opinions that stimulate the reader, even when he doesn't agree. As Phillips has long been interested in subspecific variation, the book seems markedly directed to the taxonomist. It is disturbing to find that some scientific names have been changed and that some common English names are given, without reference to the "official" names found in the *American Ornithologists' Union Check-List.* This may puzzle the general reader, who goes to "Peterson guides" for identification. Such annoying details should not impair the book's unquestionable value for the more experienced ornithologist. There is a useful, short introductory account of habitat changes in Arizona. But it is a great disappointment, considering the unrivaled knowledge of the three authors, to find no general treatment of local avian zoogeography and no discussion broadly correlating Arizona ecology with bird distribution.

Each species that occurs regularly in the British Isles—some 320—is illustrated in color in *The Oxford Book of Birds,* with a text by Bruce Campbell. Any bird believed to have reached Britain on its own, even once, is commented upon, including some North American land birds recently observed. The book is about twice the size of a field guide, and the full-page plates by Donald Watson, showing three or four species with their habitat as background, are pleasingly composed. In almost all cases, Watson has succeeded in depicting a characteristic posture; evidently he knows most of the birds in life. Opposite each plate is an account of each species, giving data on identification, its British habitat, and informal, informative comments on life history. A novel abbreviation system indicates the months in which a species occurs in Britain and when it breeds. There are short but, to a beginner, useful sections on classification and the major characteristics of the various bird families—their anatomy, flight, behavior and breeding, migration patterns, and

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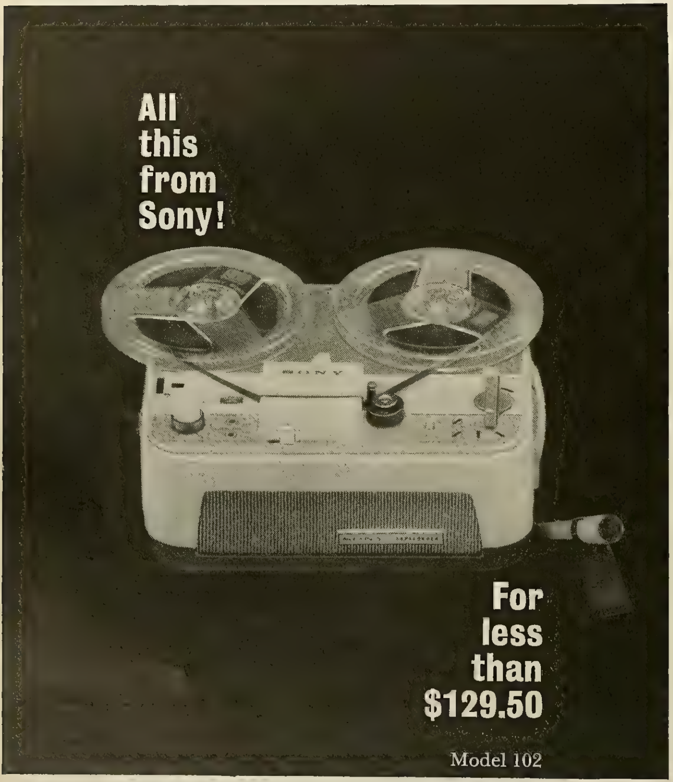
longevity. While most of the textual information can be found in one or another of the many current British bird books (a number of which are listed in an appended selective bibliography), this work seems to be aimed primarily at those inexperienced in bird study. Its language is commendably succinct and direct, avoiding any hint of patronizing or of coyness.

*Song and Garden Birds of North America* is the first of a projected two-volume work of the National Geographic Society to cover all major bird species north of Mexico. It replaces the long-out-of-print and justifiably successful *National Geographic Book of Birds,* also a two-volume set, which was originally priced at $5.00. Judging by the $11.95 price for this first volume alone, the new set will cost more than four times as much as the earlier publication. The National Geographic Society must feel assured of an enormous mail-order sale among its vast membership, for the first printing is 300,000 copies.

The main attraction is the color photography, which shows a fair proportion of the land species in the United States—from hummingbirds to songbirds. Most of the photographs are good; many were previously published in the *National Geographic Magazine.* In addition, there are numerous color drawings, chiefly by Allan Brooks, taken from the old *Book of Birds,* and some new ones by W. A. Weber and G. M. Sutton. A novel feature is a pocket insert holding a little record album of songs of seventy species, selected from the collection of the Cornell University Laboratory of Ornithology. The quality of reproduction is excellent. On the title page, authorship is credited to Dr. Alexander Wetmore, undoubtedly one of the world's most distinguished ornithologists, "and other eminent ornithologists"—presumably those whose names appear on the credit page as having written certain chapters. Some parts, such as the chapters by Wetmore, that on field identification by Roger Tory Peterson, and the preliminary section on hummingbirds by Crawford H. Greenewalt, sound as if these authors actually wrote them. But the style of most of the other sections suggests that what the other eminent ornithologists prepared has suffered a profound sea change.

Apparently each of these men submitted merely an introductory general section on the bird family assigned to him. This was then revised by *National Geographic* staff writers, who also presumably supplied such saccharine subtitles as "Jeweled Lilliputians on Slender Wings," "Brownies with Big Voices," and the like. The main text, comprising the accounts of each species (and some family introductions without author credit), seems to have been compiled by anonymous staff writers. A text prepared by persons unfamiliar with birds betrays itself by surprising errors. What experienced bird student would say: "The yellowthroat seldom visits settled areas," when during migration it is one of the warblers most often seen in suburban shrubbery and city parks, where it not infrequently breeds? What basis is there for asserting that in purple martin colonies the first claimants are the "young, unmated males" and that the "last to arrive" are "old pairs," when published studies indicate the reverse? But far more disturbing than such occasional errors is the style, which evidently reflects—and certainly encourages—a condescending attitude toward those interested in bird study. The *National Geographic* editors must believe that a bird book cannot be sold to its members unless it is written with the sentimentality and preciosity that many of us thought had disappeared with Queen Victoria. "Human interest" is constantly injected by pictures of a cute child or a pretty woman. And as for the tone—let a few examples speak for themselves. "Up from the greening field he whirls, a small brown bird singing a song of gold"; "Dark eyes sparkling through his roguish mask, this excitable little bird diligently hunts for caterpillars." The prose



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of professional scientists may require editing, but must an editorial staff convert what is written on birds into elfin twitters? Doubtless a good proportion of the millions of National Geographic Society members will buy this book. That proves only a wide interest in birds, the appeal of bright color, and the loyalty of the membership. A book written in unaffected English (like the earlier work) would surely sell as well. After all, the membership is a group with better-than-average education and with a demonstrated interest in nature. If the general public avidly purchases hundreds of thousands of copies of the "Life Nature Library," written in direct and unpretentious English, published by an admittedly commercial organization, are we not entitled to expect that "a scientific and educational organization for increasing and diffusing geographic knowledge" should aim as high? And as to increasing geographical knowledge in regard to birds, why does not the Society use its enormous resources and assured outlets in providing illustrations of the rich, but virtually unpictured, bird life of tropical America? This would certainly seem to be of far greater value than repeating illustrations of United States birds, which commercial enterprises have been doing adequately (almost *ad nauseam*), at less cost to the public and with evident profit.

*Eugene Eisenmann is a Fellow of the American Ornithologists' Union and a Research Associate in the Department of Ornithology at The American Museum.*

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INDIAN ART IN MIDDLE AMERICA, by Frederick J. Dockstader. *New York Graphic Society, $25.00; 221 pp., illus.*

THE Museum of the American Indian, of which the author is Director, is a fantastic storehouse of archeological and ethnological objects from the aboriginal New World, collected over many years by the late George Heye. The value of Dockstader's book is that it illustrates many pieces from this collection, some from modern tribes, which would otherwise remain unknown. The coverage ranges all the way from northern Mexico through Panama, and even includes the West Indies, although certainly no anthropologist would group those islands with Middle America.

In a market fairly glutted with expensive books on pre-Columbian art, one may fairly ask whether this one is worth the price. The text is undistinguished and in many places inaccurate, especially when dealing with peripheral regions less well known to archeology. Dockstader commits the fallacy of misplaced concreteness by affixing dates to *all* the specimens he shows. In the case of the

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AVIANCA, The Colombian Airline, has coordinated a tour based on the recent and well received book, THE BIRDS OF COLOMBIA. The author, Mr. R. Meyer de Schauensee, is Curator of Ornithology at the Academy of Natural Sciences of Philadelphia, and is acting as Scientific Consultant to the tour.

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tomb figures of western Mexico, their placement in time is not always known, but in many other instances the dates given to objects are definitely wrong. The quality of the black-and-white illustrations in gravure is very high, while that of the color plates is correspondingly low, a situation found in other books printed in Italy.

All in all, *Indian Art in Middle America* is recommended mainly for those specialists and enthusiasts who wish to see a sample of the riches available in a great and little-known museum.

MICHAEL D. COE
*Yale University*

THE AMBIDEXTROUS UNIVERSE, by Martin Gardner. *Basic Books, Inc., $5.95; 294 pp., illus.*

ONE may think of the laws of nature as being related to each other in such a way as to form a labyrinthine edifice designed and constructed by The Master Builder. Man, as a scientist, has set himself the task of mapping this structure by discovering and relating the laws of nature. Martin Gardner follows the mappers around very closely, and has unraveled his own ball of twine. In this fascinating book he takes the reader on a guided tour of those rooms and interconnecting corridors whose walls may, or may not, be mirrors. He discusses left- and right-handedness in gloves, ears, molecules, and elementary particles, and the origin of life here and elsewhere. Life-processes make and use asymmetric molecules of one-handedness but not the other. So, perhaps, "looking-glass milk" may not be good to drink because its molecules are reversed. The narrative is far-ranging, and every paragraph is thought-provoking. Mr. Gardner obviously enjoys the world, an attitude that will infect the reader of this work every time he reads it.

K. L. FRANKLIN
*American Museum-Hayden Planetarium*

WILDLIFE BIOLOGY, by Raymond F. Dasmann. *John Wiley & Sons, $5.95; 231 pp., illus.*

ONE of the outgrowths of the mismanagement of the environment by man has been the rise of the profession of wildlife management. Although still a youthful profession, its advances over the past few decades have been quite remarkable. Not only must the wildlife manager be competent to know what must be done in a region; he must also be prepared to sell his program to a highly resistant, ecologically uneducated legislature and public.

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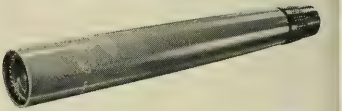

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ology of wildlife and how it is studied. The examples are drawn from all parts of the world; the text is well documented and organized. The tables and figures are clear and pertinent, and the photographs are appropriate and well reproduced. The book is beautifully designed. Although textbooks are not usually reviewed on these pages, this one is valuable for those who wish to study a field that is of great importance to the future of the larger mammals of the world.

Richard G. Van Gelder
*The American Museum*

American Gem Trails, by Richard M. Pearl. *McGraw-Hill Book Co., $5.50; 167 pp., illus.*

It would seem that everything in the present book has already been covered in the author's eighteen other books, all of which are listed opposite the title page.

However, author and publisher are apparently agreed on the principle of the shotgun approach. The size of the book and the quality of the information therein might qualify it as a 50-cent paperback, but not as a $5.50 hard-cover book. In fact, the price is outrageous for 167 small pages, about half of which are text. The distribution maps are on such a small scale that it is quite impossible to identify the specific localities referred to. According to the cover blurb, "These maps serve as useful aids to the gem and mineral explorer." With this statement, the author and publisher lay themselves open to charges of grave misrepresentation. It may be true that "there's one born every minute," but I am surprised to find the McGraw-Hill Company apparently succumbing to the doctrine by publishing this book.

Brian H. Mason
*Smithsonian Institution*

African Sculpture, by William Fagg and Margaret Plass. *E. P. Dutton & Co., $1.75; 160 pp., illus.* Senufo Sculpture from West Africa, by Robert Goldwater. *The Museum of Primitive Art, $8.95; 126 pp., illus.*

William Fagg and Margaret Plass have written a book on African sculpture that breaks away from many of the old traditions set by previous books on that continent's art. It is a paperback, so it is portable and low-priced; more important, there is a wealth of photographs (at least one to every page) of many objects that have never been pictured before. The authors are not, in their own words, setting out "to present the 200 greatest Masterpieces of African Sculpture," nor (another departure) are they rehashing the usual presentation that places all importance upon a series of geographic areas, forc-

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ing the material into tightly compartmentalized "styles."

The pieces are arranged according to their "artistic sympathy" so that they may be examined in relation to European concepts of art. But lest the reader raise an eyebrow at such a blatant unveiling of what has been a long-hidden *modus operandi* among "experts" on primitive art, the authors insist that they are doing this merely to see what comes of it and warn that "if we find convergences of form, however striking, between tribal and modern art, we must not assume any identity of purpose, inspiration, or real content." And, they suggest, the reader who does not wish to be "encumbered with our attempted correlation of European and African modes" may use the book as a "museum without walls."

And indeed it can so be used. The quality (as well as the number) of the photographs is remarkable for a paperback publication. Once the introductory disclaimers are digested, the whole arrangement of the book leads one to explore the text, and its often frankly subjective nature largely achieves what the authors wish—stimulating the reader to think about African art in new and different terms.

The last section, which claims to abandon the comparative technique and to treat African sculpture per se, is rather disappointing. As a social anthropologist, I should like to have seen, at this point, a truly perceptive placing of art in its total social context. The general reader, and many a specialist, could well do with such a guide.

*Senufo Sculpture from West Africa,* by Dr. Robert Goldwater is larger, more expensive, and more conventional. The objects selected for the excellent reproductions can be called typical only if one takes a very idealized view of traditional African sculpture—for these are masterpieces and therefore exceptional.

Evidently not believing that art is quite such a universal language as it is often made out to be, Dr. Goldwater gives the reader a fine introductory section discussing the significance of the carvings, their ritual usage, and their connection (alleged or otherwise) with secret societies. Marginal notations refer the reader to specific photographs, and the resultant page turning points up the great advantage of the humbler paperback format used by Fagg and Plass. The book ends with an excellent section, illustrated, on contemporary carving for the tourist trade.

Dr. Goldwater also does a valuable job in presenting people before he presents things—which is as it should be.

COLIN M. TURNBULL
*The American Museum*

EARLY ANTHROPOLOGY IN THE SIXTEENTH AND SEVENTEENTH CENTURIES, by Margaret T. Hodgen. *Univ. of Pennsylvania Press, $12.00; 523 pp., illus.*

If it takes a wise child to know its own father, then anthropology, Dr. Hodgen suggests, has been lacking in wisdom. In a science concerned at least in part with the development and history of human culture, a corresponding interest in the history of the ideas that engage its attention has been curiously perfunctory and immature. Only a few names come to mind of scholars seriously interested in the intellectual history of anthropological concepts, and none of them has penetrated as deeply or made as much sense as Dr. Hodgen.

For the most part, we are taught that anthropology is a young discipline, scarcely a century old, and if we stretch it a bit to include a few forgotten precursors, we might go back as far as the latter part of the eighteenth century. This, however, turns out to be far from the truth. Although the author makes a dutiful but questionable bow to Herodotus, who was essentially a collector and not a scholar or scientist, she really traces the beginnings of modern ideas about man and his culture to the period that saw the end of the Middle Ages and the dawn of the Renaissance. The medieval compendiums, full of anthropophagi, monsters, and bizarre customs culled from Pliny, Mela, Solinus, and other classical sources, gave way slowly and bit by bit to the flood of new knowledge that was being acquired by the expanding world of Europe.

All this new information, brought back by explorers, missionaries, and traders, not only required a revision of the fantastic, frozen world inherited by the medieval mind; it raised fundamental questions that demanded answers. It was not merely the novelty that new races of men and their exotic customs presented; more significantly it was the necessity of reconciling all this with systems of belief based on biblical authority. Although the solutions achieved were in terms that strike our ears as somewhat naïve, nevertheless the results laid out the issues that have remained with us to this day.

Dr. Hodgen's brilliant interpretation of this neglected literature has added a new perspective to anthropological thought. The cavils, the doubts on minor details, are of little importance against this major achievement.

HARRY L. SHAPIRO
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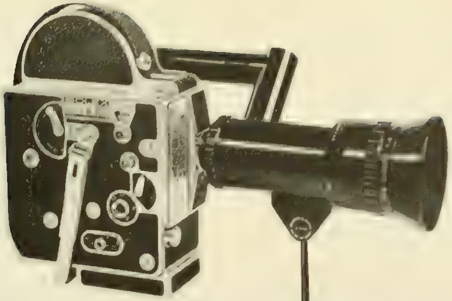

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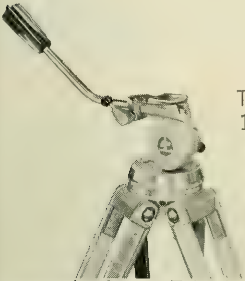

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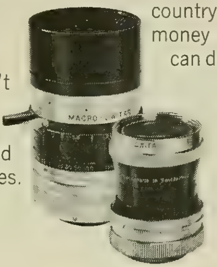

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# Trinidad and Bat Research

### By Arthur M. Greenhall

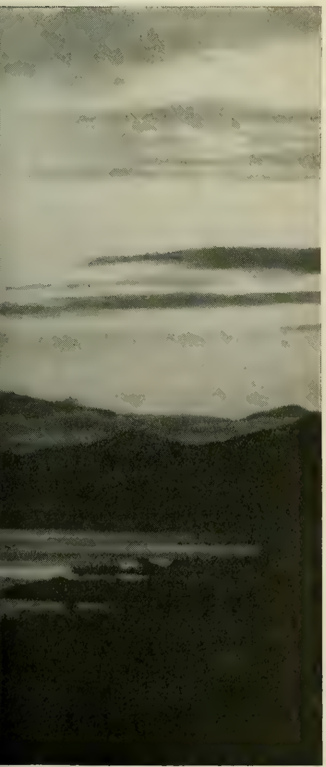
**Insect-eating**, long-nose-leafed bat, *Lonchorhina aurita*, is found in the West Indies, South America, and Mexico.

**Only** the Gulf of Paria separates Trinidad from the South American mainland, complicating bat control on the island.

# Caribbean island has been study area for almost a hundred years

Recently, while seated at my desk beside the windows facing Trinidad's northern range of hills, it occurred to me that of the bat collections and observations that have been made here over the past one hundred years, most were made within a short distance of this spot—the Royal Victoria Institute Museum in Port of Spain.

The more I thought of this, the more convinced I became that for the study of bat ecology, the epidemiology of bat-associated diseases, and the evaluation of bat control measures, Trinidad is without peer. Within a radius of two miles from my museum office, I can conduct field studies or work in my laboratory, which is in the Trinidad Regional Virus Laboratory of the University of the West Indies. In fact, I can even pursue my field work within the museum itself, for fruit bats fly in through the open windows at night and defile exhibition cases and walls with their droppings. Several species of fruit bats can be observed feeding or roosting in the row of eight palm trees in front of the building. A colony of the rare, insectivorous sac-winged bat, *Peropteryx macrotis*, occasionally roosts on the rafters over the stage of the museum's lecture hall. I can always tell when they are present by their sweet, inoffensive smell, quite unlike the musky odor characteristic of many bats. Sometimes the large, frugi-carnivorous greater spear-nosed bat, *Phyllostomus hastatus*, flies over the audience's head during a performance. I have even caught—accidentally—the short-tailed fruit bat, *Carollia perspicillata*, in ordinary mousetraps baited with fruit and set on our museum workbenches, and in Memorial Park, across the street from the museum, I make regular observations on wrinkle-faced bats, *Centurio senex*.



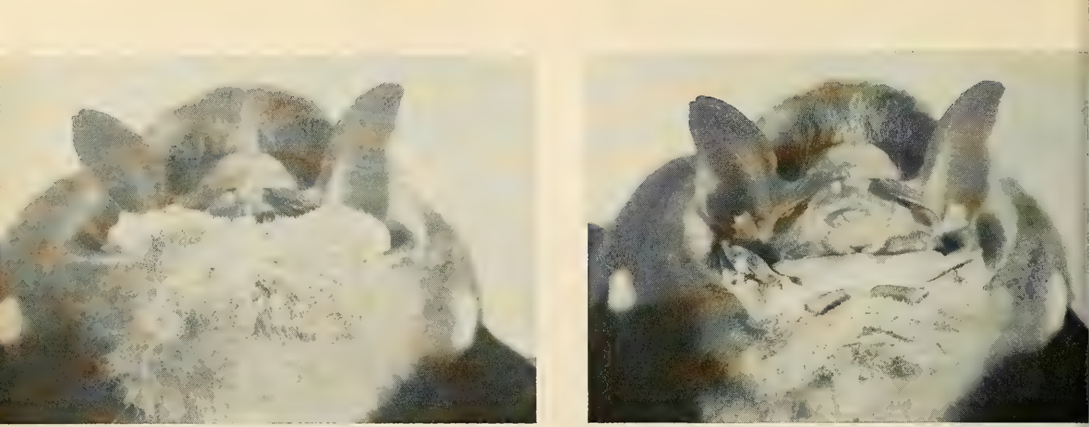
From my office window I look north across the tennis courts to the Queen's Park Savanna, where in 1925 hundreds of cattle were the first-recorded Trinidadian victims of the "mysterious disease" now known as bat, or paralytic, rabies. In the Botanical Gardens, beyond the Savanna, numbers of bats were first collected in the 1800's and described as several new species. In these Gardens—and on the site of the present zoo and a previous Government House—Charles Kingsley wrote his book *At Last*, almost one hundred years ago. It included his observations on the fish-eating bat, *Noctilio leporinus*, that he, and later his brother, watched fishing in the Gulf of Paria, which separates Trinidad from Venezuela. Eastward from the zoo is the old Governor General's House, soon to become the National Museum and Art Gallery of Trinidad and Tobago. Here, during a bat rabies outbreak in the 1930's when eighty-nine people died from the bites of infected vampire bats, large roosts of vampires were removed until the place was bat-proofed with screening. Vampires have not been taken from old Government House for years, although occasionally they attack deer, peafowl, and domestic livestock in the nearby Emperor Valley Zoo.

In 1929, the first human being died from bat rabies in St. Ann's, Trinidad. No human deaths from rabies have been recorded on the island since 1937, but people are still bitten [illegible] by vampires. The rare white-winged vampire bat, *Diaemus youngi*, has been found within a block of my house, and from my front door, I have conducted daily studies of the house-dwelling, free-tailed bats of two species, *Molossus ater* and *Molossus major* (sometimes called *Molossus molossus*), as they emerge in great numbers from under my neighbor's corrugated iron roof; he also has a fine, tall royal palm tree with fruit bats roosting among its fronds. The people who live directly over me have regular invasions from *Carollia perspicillata* when guava and various other bat-attracting fruits are ripe in the yard, while *Artibeus lituratus*, large Trinidad fruit bats with a twenty-inch wingspread, "steal" ripe bananas and mangoes out of the fruit bowl on the dining-room table. The bats do not really steal the fruit, since a different fruit is usually substituted by the bat. I devised ways to frustrate the marauders with newspaper and tinfoil "traps" and to prevent fruit pilferage and bat mess on walls. I welcome the fruit bats that occasionally roost in our fruit trees, as this facilitates photographing them.

I set nylon mist nets in our yard and caught an amazing variety of species, including various long-tongued, fruit-eating bats, *Phyllostomus discolor*, *Glossophaga*, and *Anoura*. They pollinate such trees as the silk-cotton, calabash, and banana while feeding. The fringe-lipped bat, *Trachops cirrhosus*, is a lizard feeder that catches chattering, nocturnal geckos frequently found hiding during the day behind paintings in our house.

Much has been written about Trinidad bats in the years since Columbus discovered the island in 1498 and vampire bat predation was first reported. During the second Spanish occupation, about 1591, a locality in the Montserrat Hills of central Trinidad was called *mousiegalal* (a corruption of the Spanish *murciélago*—bat). The name is no longer used, but it is interesting to note that in these same hills are found the large Mount Tamana bat caves.

In 1856, Gaston de Verteuil, a noted



**Wrinkle-faced bat,** ***Centurio senex,*** **sleeps with its face completely covered by a fold of loose skin from under its chin. Skin is held in position by a knob on the top of the head, and is released when bats are aroused. *Centurios* are**

Trinidad historian, remarked that "Bats may be said literally to swarm in Trinidad, both in town and country. Sometimes an immense number of them take their lodging in the hollow of some large tree from where they are seen issuing by hundreds to venture on depredatory excursions. Many live on fruits, and some sucking blood, not only of animals, but of man; they are so numerous in some parts, that instances of persons having been bitten several times in the same night are not rare. . . . The loss of blood from numerous or repeated bitings is, at times, so great that large animals such as oxen become immediately enfeebled and may die within two or three weeks; this, however, happens only at intervals of several years, when great loss in livestock is occasioned to proprietors of estates. They attack also swine, and even fowls."

There is little variation in the picture a hundred years later, even in well-developed and densely populated areas. The historical chronicle of the periodic losses of livestock bears an unusual resemblance to the outbreaks of paralytic rabies recorded at approximately five-year intervals since 1925. We know that bat rabies is endemic and cyclic in Trinidad and I have been able to predict epizootics on two occasions by observing general bat population behavior, especially in vampire roosts, and interpreting other abnormal factors. This has included attempts to ascertain the incidence of bat rabies and other viral diseases in the Guianas and Venezuela.

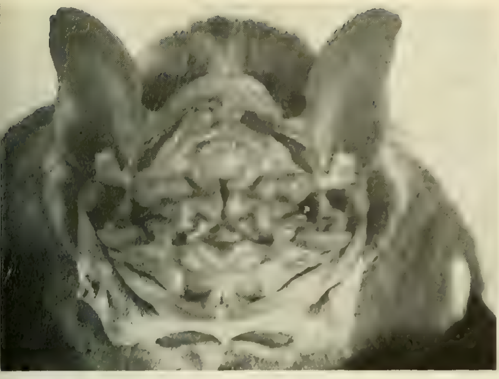
When I settled in Trinidad with my family in 1953, thirty-four species of bats were recorded for the island. This accounts for about half of the entire mammal population. In 1963, the list numbered sixty-two for Trinidad, excluding Tobago. Almost one-third of these species were not clearly identified until investigated in Trinidad, and of these, ten can be found in various places in Port of Spain. Most of them were caught in the Botanical Gardens between 1838 and 1958. The naked-backed bat, *Pteronotus davyi,* first described in 1838, is a unique New World insectivorous animal whose wings are attached to the middle of the back. This results in a bare-backed appearance, although there is in fact fur on its back as in other species whose wings are attached in the usual manner at the sides.

STUDIES have shown that Trinidad probably has the largest, most varied bat fauna of any country of comparable size, 1,864 square miles (about the area of Delaware). It includes representatives of all the nine bat families found in the New World: (1) reflex-winged bats, Emballonuridae; (2) bulldog bats, Noctilionidae; (3) leaf-nosed bats, Phyllostomidae; (4) vampire bats, Desmodontidae; (5) funnel-eared bats, Natalidae; (6) thumbless bats, Furipteridae; (7) sucker-footed bats, Thyropteridae; (8) smooth-faced bats, Vespertilionidae; and (9) free-tailed bats, Molossidae. Trinidad's proximity to the South American mainland probably accounts for this rich bat fauna.

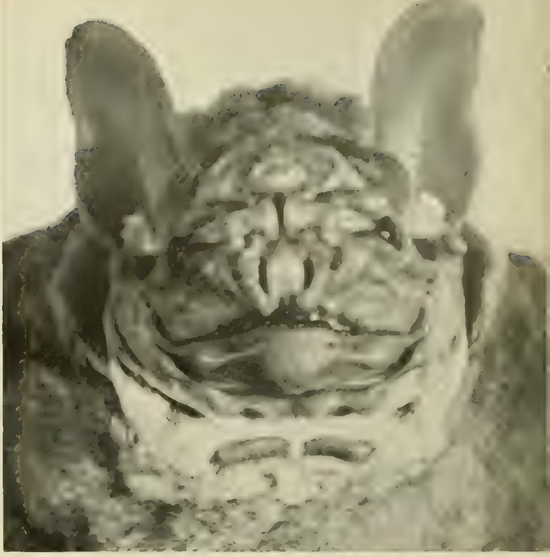
Except for bat collectors, these flying mammals attracted little general attention in Trinidad until 1931, when the government's pathologist, Dr. J. L. Pawan, discovered that bats were transmitting a type of rabies and possibly other diseases to man and beast. This explained the mysterious epidemics in the 1920's that had killed cattle in the Queen's Park Savanna and had claimed the first human lives. The details of Pawan's work (considered one of the great epidemiological detective stories) was discussed in NATURAL HISTORY, February, 1952.

Although the common vampire bat, *Desmodus rotundus,* was the most obvious carrier because it feeds exclusively on blood, the first bat found infected was a fruit bat, *Artibeus jamaicensis* (then called *planirostris*). Also under suspicion was the spectral, or false, vampire, *Vampyrum spectrum,* the largest New World bat, with a three-foot wingspan and a rat-sized body. This carnivorous species feeds upon birds, rats, mice, and other bats. Early explorers and naturalists believed that this large animal was the true blood-feeding vampire. As investigations continued in Trinidad, six other species were added to the records of rabies-infected bats, but *Vampyrum,* up to 1963, had not been associated with any disease.

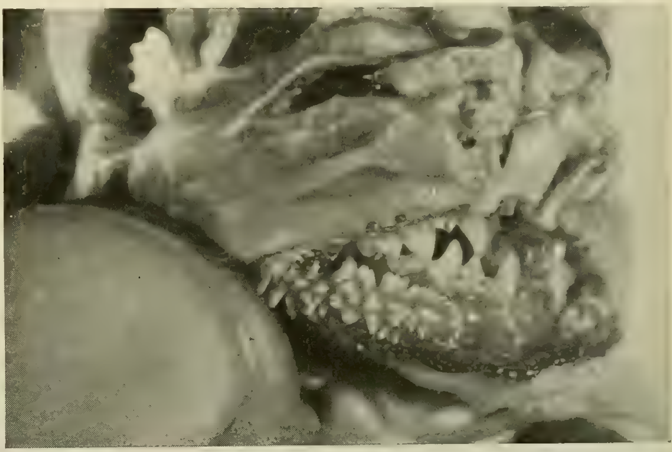
A third large epidemic of bat rabies appeared in Trinidad in 1934, and in the summer of that year I was invited to join the investigative team studying the habits of the infected species. Since that time, the island government has maintained an uninterrupted vampire bat destruction program. Methods of control remained substantially the same until 1954, when again, following a widespread outbreak of rabies,



probably equipped to distinguish light and shadow through two translucent spots in mask when the face is covered.



**Centurio** appears at once alert and malevolent when the wrinkled chin flap is folded and face wholly bared, *right.*



**Skin** between *Centurio*'s lips and its gums is covered with myriad papillae that may be used as strainers and to aid the bat in eating fruits and juices.

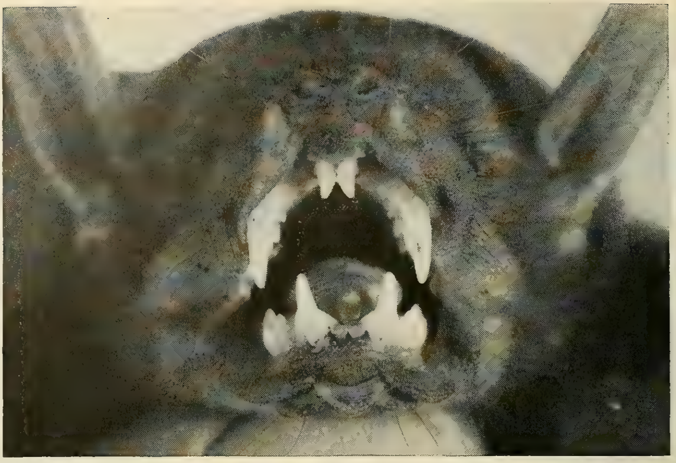
the government put me in charge of research to seek more efficient controls. This request followed closely on the interest in bats generated in the United States (where no vampires occur), when the first rabid insectivorous bats were found in 1953.

In the midst of Trinidad's rapidly increasing industrial and urban expansion, vampire predation remains intense, while several insect- and fruit-eating species are so numerous they can now be called house bats. It is interesting to speculate why certain free-tailed bats, *Molossus ater* and *M. major,* are attracted to the undersides of metal roofs where temperatures of 130° F. have been recorded, preferring these to their previous, "air-conditioned" roosts underneath palm fronds. These house-loving bats infest private dwellings in Trinidad by the hundreds, much to the annoyance of the people who must daily listen to their noisy thumpings and scuttlings. Apart from the psychological elements and the public health problems associated with house bat infestation, there have been occasions when the accumulation of guano has been so great that ceilings have collapsed, cascading hundreds of pounds of droppings to the floor below.

Proximity to the South American mainland complicates bat control in Trinidad. Trinidad lies in the delta of the Orinoco River, and is the southernmost island of the West Indies, separated from South America at two points by about six miles of the Gulf of Paria. However, control measures can be conducted and evaluated more easily on an island, as was the case with the eradication of the screwworm (by antifertility measures on Curaçao in the Netherlands Antilles).

But the island to mainland relationship is of significance both to zoologists and to public health investigators. Trinidad is a natural bat laboratory. Within a thirty- by forty-mile area as many bat species have been discovered as are recorded for all of North America that is north of Mexico.

With bats of all kinds ubiquitous, it is not surprising that Trinidad folklore prominently features a bloodsucking evil spirit, or *jumbie*, known as the *soucouyant.* When country people are bitten by vampire bats, they are often unshakable in their conviction that the *soucouyant* has attacked them, although they recognize that it is bats that attack their livestock. The *soucouyant* is thought to be an old woman who sheds her skin in her house at night, hides it—usually under a mortar for grinding grain—and flies off



**Large** and powerful *Noctilio leporinus* has cheek pouches for carrying its food.

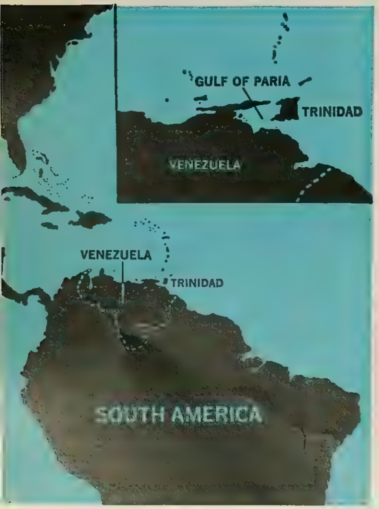
**Sensitive** hearing of *Noctilio* helps it echolocate fish if a fin breaks surface.

through the air as a ball of fire. She can only pass through a keyhole or crack in the house to attack some person for her nightly meal of blood. There are several methods of trapping this evil spirit. One is to locate the shed skin and sprinkle hot pepper on it; this burns the *soucouyant* to death when she replaces her skin. A less severe method is to scatter several pounds of rice outside her house, since she must count these, grain by grain, before she can re-enter. Complete household protection may be afforded by eliminating keyholes and filling all cracks in the house.

SINCE 1953 I have worked on various zoomedical and socioeconomic relationships between man and bat in Trinidad, and numbers of scientists have come to study or collaborate on a variety of projects. These include taxonomic problems; vampire, fruit, and house bat control; bat-associated diseases, such as rabies and histoplasmosis; bat anatomy, physiology, and echolocation; and plants pollinated by bats.

My own special interest is the family Desmodontidae, which includes *Desmodus*, *Diaemus*, and *Diphylla*. Restricted to the Western Hemisphere, these three genera of vampire bats present a unique American problem of public health and economic importance from northern Mexico to Argentina. Excluding the disease factor, repeated vampire predation is debilitating to livestock and humans, for a single *Desmodus* can account for a loss of up to two ounces of blood nightly. This is a combination of the amount consumed directly, plus up to twenty minutes of seepage from the wound. Since as many as five hundred vampires may congregate in a single roost, their presence in an area creates a problem in any country attempting to achieve self-sufficiency in livestock production, whether it be on the large cattle ranches of Mexico, Central and South America, or in small, but densely populated, Trinidad.

Both *Desmodus* and *Diaemus* occur in Trinidad and the presence of *Diphylla* is suspected. No vampires have been reported from the neighboring island of Tobago. I have studied the common vampire, *Desmodus rotundus*, since 1932 and have observed its behavior in a number of countries throughout Latin America. I maintain a breeding colony of about forty in the Trinidad Regional Virus Laboratory and compare my findings with a field colony of approximately the same size located in central Trinidad. In collaboration with the Lister Institute



**Fruit-eating** *Chiroderma trinitatum* is found only on island of Trinidad.

**Teeth** are placed obliquely in row, with widely spaced incisors, at right.

of Preventive Medicine in England, the laboratory is investigating the host preferences of Trinidad vampires. Initial findings indicate that the domestic animals most commonly attacked are cattle. The vampire in Trinidad also feeds upon some unidentified wild animals. Further, a single vampire feeds upon several different hosts in a single night, as well as returning to one host for successive feedings. One *Desmodus* we studied had traces of human and cattle blood in its stomach; we also discovered that there were traces of equine blood in the fecal material of the same bat.

The white-winged vampire, *Diaemus youngi*, is particularly noteworthy. The first specimen found in Trinidad was killed in 1954 as the bat attacked a fowl in a tree in the Santa Cruz Valley. Shortly thereafter, a breeding colony of about thirty was found in a hollow tree in south Trinidad. Until that time, it had only been known from a few museum skins and was thought to be confined to South America. Since 1954, more of these vampires have been found in Trinidad, and they have been collected as far north as Mexico. When caught, *Diaemus* opens its mouth, and two cup-shaped glands located on each inner side of the mouth may be turned facing outward like two small cannons. The bat then makes a sudden, explosive, hissing sound, like "psst," and emits a powerful, foul-smelling odor. Extraction tests made on the contents of this gland showed the presence of several common amino acids and an unidentified compound containing sulphur. A further butanol extraction test suggested that the odor of the secretion may be pleasant in itself, but that it may be masked by unpleasant odors produced in the cup of the gland. These glands are not present in any other bat and their use is not yet known.

In captivity, *Diaemus* has refused cattle blood even when mixed with chicken blood, although it feeds readily upon the latter when it is undiluted. Yet, one herd of cows has repeatedly been attacked by *Diaemus*, and field observations show that it feeds on goats, donkeys, poultry, or pigeons.

*Diaemus* is an extremely vocal bat that utters a variety of hisses, screams, whistles, and chirps. Unlike *Desmodus*, mated pairs appear to be devoted to each other. They are gentle and seem to be distressed when separated. On seeing its own reflection in a mirror, one *Diaemus* licked the glass in apparent recognition. When reunited after a separation of less than five minutes, the *Diaemus* pair put on a demonstration of affection that would rival any film romance.

One afternoon, eight squawking Amazon parrots in a tree outside my office provided a welcome excuse to set aside a dreary budget report. Crossing the street into Memorial Park, I remembered that the evening before, as I had passed the park on my way to the cinema, I had recognized a characteristic, powerful odor. I knew I would find the wrinkle-faced bat, *Centurio senex*, in a row of *Putranjiva* trees. Hanging in groups of twos, threes, and fours, there were sixteen of these amazing animals in the dense foliage. Every time I have observed this species—perhaps the weirdest of all bats—beginning with the first two males caught in this same tree in November, 1958, I have discovered something new and unusual. For example, nine males were collected from this tree in November, 1959; then twelve more males in November, 1960; fourteen more—again all males—in November, 1961; and now sixteen hung in the identical tree in 1962. From where I stood, it was impossible to tell whether these were males, since they were about fifteen feet up, dangling like fruit, and swaying every time a breeze stirred the leaves and branches. My collection of dead bats was now large enough, so I planned to observe these as living specimens. I wondered whether there might be a female in this group, knowing that in January, 1961, a female (which gave birth to a single male in our bat laboratory) had been collected from this tree. As soon as possible I planned to issue an order to the government bat collectors to leave these "Old Man" bats, as they are called, alone. From past experience, they would remain until about March, then disappear, and return in November.

*Centurio* is light brownish in color, with a white spot on each shoulder. Its head is about the size of a ping-pong ball; its face is short, broad, and naked with a double harelip; and this unattractive whole is completely covered with wrinkled, fleshy outgrowths of skin in which are buried the relatively large, blackish, beady eyes. *Centurio* has a wingspread of about twelve inches, and flies with a wobbly, jerky butterfly motion, holding its body vertical to the ground so that the wing membranes are clearly seen. Unlike other bats, the flying membranes between the fourth and fifth fingers are striated with contrasting dark and light, narrow transverse bands, the latter translucent, producing a latticed effect. But these are not the only translucent structures. When sleeping, *Centurio* covers its face with a fold of skin from under the chin, pulling this membrane up past mouth, nose, and eyes and extending it over the flaps of the ears that lie flat across the top of its head.

White-lined bat, *Vampyrops helleri*, cuts leaves to make tentlike retreats.

Big-eared *Micronycteris minuta*, seen at right, is an eater of fruits and insects.

White-winged vampire bats, *Diaemus youngi*, prefer bird to mammal blood.

On the crown of the head is a small bump that serves as a "doorstop," and the wrinkled chin skin is stretched tightly over the face. In the middle of this facial mask, most specimens have two bare, translucent windows covering the eyes, presumably enabling the bat to see light and shadows even when the face is covered. In laboratory specimens, I was able to pull this skin mask away from the bat's face and to see light and moving objects through it. The bat unshrouds itself when aroused and the covering skin mask slips from its face into the normal folded position under the chin; the two windows then appear merely as fleshy bumps. Some large chin lappets of loose skin (not part of the mask) probably contain scent glands, as there is usually a musky, skunklike odor about the head.

Photographs of a bat sleeping in a tree are listed under unfinished business, along with keeping *Centurio* alive in captivity. I do not know this bat's diet. Yellow fruit pulp was found in the stomachs of some bats examined. Perhaps they feed on the flesh and juice of fruit from the *Putranjiva* tree. We always found masses of large seeds under the trees where bats were roosting—more seeds from more kinds of fruit than any *Centurio* could eat, indicating other species of bats roosted in the same place. Fruit-eating *Artibeus* bats were also found in the trees.

The skin between *Centurio*'s lips and gums is covered with many fleshy papillae, and I surmise that the bat uses these outgrowths as strainers and perhaps feeds upon soft, pulpy fruits or their juice. When the bat's mouth is opened, the throat opening is seen to be tiny; it was only between 1.3 to 1.4 mm. in several specimens. Rough dissections show a second opening of about the same size which, in turn, leads into a saclike structure, which narrows into an esophagus. All of this suggests that the animal "sucks" and "strains" its food, as indeed it seemed to do when fed mushy bananas, pawpaw, and juices of several other fruits.

In Trinidad we have found a few *Centurio* under the leaves of mango and rayo (*Dracaena* sp.). It is primarily a solitary bat preferring the company of other *Centurio*. On one occasion, however, when we were live-netting a number of large fruit bats (*Artibeus literatus*) from under some leaves in the Botanical Gardens, we were astonished, on emptying our net, to find a lone male *Centurio*.

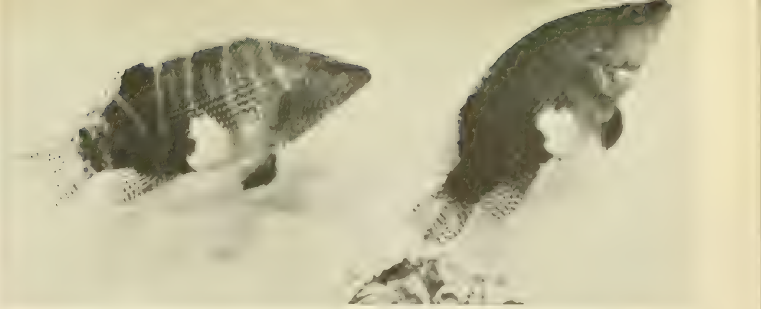
When I came upon our first Trinidad *Centurio* in 1954, I knew that until then very few specimens ever had been caught. Aside from the fact that it was classified as a stenodermine fruit eater and was known from Central America, nothing had been learned about it since it had first been described in 1842, except that some twenty-eight specimens had been collected in Guatemala by Indians who would not reveal where they had caught them. They were caught on different days—two to twelve a day—suggesting that they came from small colonies.

The week before Christmas, workmen came into Memorial Park to set up numerous Christmas trees and drape them with lights. Then loudspeakers were placed in some living trees, including my *Centurio* tree. A continuous blare of Yuletide music started before Christmas and continued until Twelfth Night, January 6. I could barely tolerate this uninterrupted cacophony drifting into the museum (even the parrots would have been welcomed back by the dozens), and I thought my bats surely must have departed. However, on New Year's afternoon, I was pleased to see that most of the wrinkle-faced bats were present and swinging gently in the breeze, apparently undisturbed by "The Twelve Days of Christmas."

**Branches of bougainvillaea vine partly hide several fruit-eating *Artibeus* bats.**

*mall grouper, about 3 inches long,*
*ft, shows swollen abdomen,*
*dicating it is ready to accept*
*mate. If none is available, it will*
*y and fertilize its own eggs.*

*During courtship, right, unbanded female-phase fish at far right swims in jerky manner that pulls it into almost vertical position. Left fish is in banded male phase.*



# Mating of Groupers

## New studies detect reversal of stripes in hermaphroditic fish

By Eugenie Clark

FROM the reproductive standpoint, one of the most extraordinary animals known is the hermaphrodite *Serranus subligarius*, a small species of the grouper family, common along the west coast of Florida. During the mating season, spring through summer, each adult individual can function as a male, a female, or both sexes simultaneously, depending on the situation.

*Serranus* live in well-defined territories, each of which is usually occupied during the spawning season by two individuals. At a certain time of day, hermaphrodites by the thousands start to spawn. Then, the stark white abdomens of these otherwise reddish-brown fish are swollen with freshly ovulated eggs. The paired fish spread their fins and twist their bodies into an S-shape. The bulging white abdomen is kept toward the partner fish as the pair chase and rotate around each other. They move with jerking movements, then swim rapidly upward, and end the maneuver in a "snap"—a sudden twist and then straightening of their bodies. During this snap the eggs and sperm are released. A pair may reach this climactic snap more than a dozen times during a spawning session.

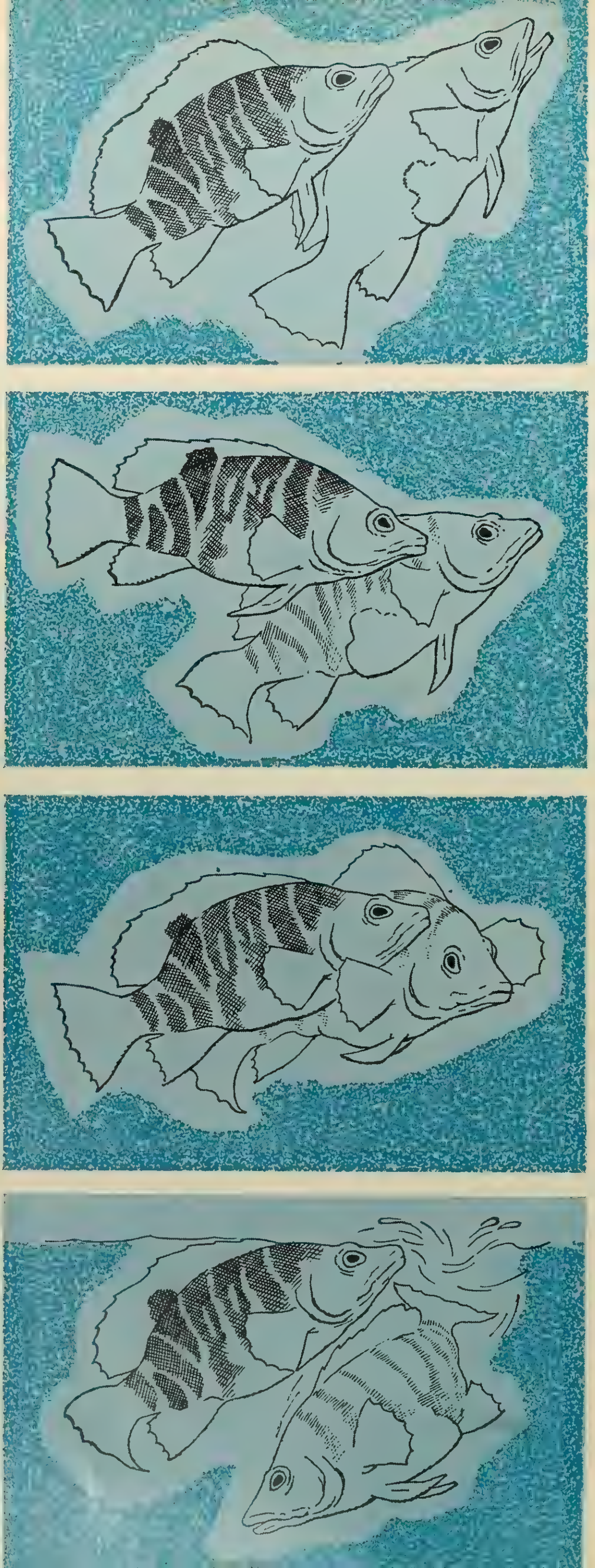
Studies in the laboratory revealed extraordinary details. The fish that chases is, as would be expected, in the male role. It then has bold, broad, dark, vertical bands on its body. The fish in the female phase is unbanded, is usually larger, both in size and in abdominal enlargement, and takes the lead during the final upward swim. These two color phases are helpful for the observer, because the fish are capable of reversing their roles within a matter of seconds. When not spawning, their color patterns vary from the banded to unbanded stage. The former is the more common, especially in young fish.

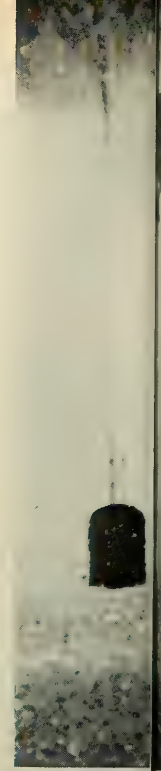
A highly interesting experiment is to place two hermaphrodites together when both are filled with eggs and unbanded. After what appears to be a frustrating attempt at courtship, the fish begin to lunge and peck at each other; S-curving and display of the white abdomen intensifies between pecks until one fish, usually the larger, manages to force the other into a corner until it appears to "give up." The smaller one then darkens into the banded male phase, comes out of its corner, and pursues the larger fish in the typical courtship maneuvers. Presently the abdomen of the larger fish is noticeably flatter, as it has expelled the eggs, while the other fish is still swollen. Then sex roles may be reversed. Several reversals may occur before the spawning period ends.

THE introduction of a third fish into an aquarium with a spawning pair can also cause a sudden sex reversal. In one situation, spawning started between a pair after the smaller had been forced into the male role. The third fish, the largest, had just spawned as a female in another aquarium, and had released all or most of its eggs. When introduced into the aquarium, it was attracted to the smaller of the spawning pair, which had the more swollen abdomen. This male-phase fish rapidly lost its bands, switched to the role of a female, ignored its previous mate, with whom it had snapped as a male a few seconds earlier, and snapped as a female with the third fish. The time between the two snaps was less than a minute. In a crowded aquarium several fish may take part in a snap. The leader in the chase, in the unbanded female phase, seems to control the climax of the upward swim.

A surprising discovery was made when studying photographs taken just before the snap. At this critical moment, the leading female-phase fish became banded! At first this confused the otherwise clear-cut courtship relationship between an unbanded female phase and a banded male phase, until I realized that banding on the leading fish is the *reverse*, or negative, of that on the male-phase fish.

Much has yet to be learned about the unusual reproductive habits of this hermaphrodite. How can it reverse its sexual roles so quickly? What controls the color changes? We are still not sure if the fish playing the male role releases a few eggs at the time the sperm are ejaculated, or if the fish in the female role is capable of holding back its sperm supply. There are definite advantages in crossbreeding, and it appears that self-fertilization is only used as an emergency method when a mate is not available. However, a good technique has yet to be developed to discover whether or not self-fertilized eggs ever result from the spawning of a pair of these odd, hermaphroditic fish.





*In photograph above, female-phase fish at left starts to twist into snap and release eggs. At that same moment it turns from unbanded to the reverse-banded, "extreme" female phase—exactly opposite to male phase (fish at center). Latter will join in snap and release sperm. A third fish in female phase stays close by. At right, center fish rubs chin on dorsal fin of "female," perhaps stimulating a snap, in which the third, banded fish may participate.*

*Sketches, left, were based on movie frames taken during upward swim. Larger, leading fish is in female phase. As it makes an abrupt turn toward its mate, the two snap their bodies and splash the surface of the water. Immediately after the snap, roles may be reversed. After several snaps, surface of water is covered with eggs in various stages of early embryonic development.*

# Insect's Scales Are Asset in Defense

## Unlike smooth-bodied prey, moths can escape from orb webs

BY THOMAS EISNER

CONSIDER for a moment the plight of a nocturnal insect on the wing. Although virtually unassailed by birds, dragonflies, and other predominantly diurnal predators, its nightly excursions are nevertheless fraught with hazards. For a species that tends to fly high and above the existing vegetation, the chief enemy is probably the foraging bat. For the one that stays closer to the ground, there is the added danger of the spider web. Other predators also take their toll, but perhaps none is more important than these two.

In the course of evolution, hazards rarely go unchallenged, and it is therefore only to be expected that some nocturnal insects should have acquired the means necessary to cope with their enemies. As has been shown through the notable studies of Dr. Kenneth D. Roeder of Tufts University, and Dr. Asher E. Treat of The City College of New York, there are certain moths with the astounding ability of anticipating and evading the attacks of bats (NATURAL HISTORY, January, 1964). Special ears on the thorax enable the moths to detect the characteristic ultrasonic chirps emitted by bats in their attempts to echolocate insect prey. When a moth hears an approaching bat, it dives downward or enters upon otherwise elusive flight, with the obvious result that it may escape capture.

Three of us from Cornell—Rosalind Alsop, George Ettershank, and I—recently chanced upon the discovery that moths are also admirably adapted to escape from spider webs. We were staying at The American Museum's Archbold Biological Station near Lake Placid, Florida, and had gone out one night on what was intended to be a routine collecting trip, when we happened to wander into an area where a certain orb-weaving spider, *Argiope florida*, was extraordinarily abundant. The webs, ranging in diameter from a few inches to several feet, could be seen virtually everywhere around us, stretched across the open spaces between the shrubs and palmettos that characteristically dominate in the region. Glistening in the light of our lanterns, the orbs were beautiful indeed, yet our interest in them was at first only casual.

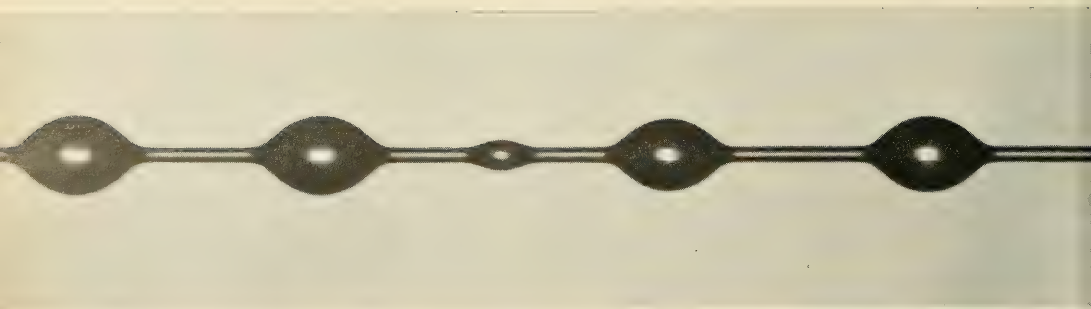
**CIRCULAR WEB** of *Argiope florida* is sometimes several feet in diameter.

WHAT eventually changed our attitude was the discovery that we could put the spiders and their webs to a most convenient personal use. All evening we had been relentlessly annoyed by exceptionally dense swarms of insects. Having failed in all other attempts to rid ourselves of them, we hit upon a simple expedient that let the spiders do the job for us. We would stand momentarily amid a crowded group of orbs, with the inevitable result that the insects would fly into them in large numbers and be quickly "sifted" from our surroundings. We were soon to become so fascinated by the spiders themselves that we spent the remainder of the night offering them prey in this peculiar fashion and observing their feeding behavior.

The web of *Argiope* conforms to a general design that is very commonly found among orb-weaving spiders. In essence, it consists of a spiral of sticky thread, the viscid spiral, superimposed on a framework of non-sticky supporting threads. The viscid thread owes its stickiness to tiny droplets of an adhesive fluid, spaced at regular intervals along the length of thread. On impact with the web, an insect adheres to the viscid threads and is detained. As it struggles to free itself, it alerts the spider, which pounces upon it, envelops it in silk, and feeds on it.

Prompted by the casual observation that moths seemed to be less susceptible to entrapment than other insects, and wishing to improve upon our technique so that we might follow more precisely the fate of individual insects as they hit the orb, we devised what we jokingly came to call the "web test." Using spot lamps, which emit an intense and narrow beam of light, two of us, each with a lamp strapped to his head, would assume positions at opposite sides of an orb. One member of the pair would then use his lamp to scan the immediate surroundings for flying insects, and when a desired form had been spotted, would attempt to lure it toward the lamp by keeping the beam fixed upon it. If he succeeded, he would then suddenly switch off his lamp and allow the insect to be "drawn" across the web to the lamp of his partner. Insects that were intercepted by the web, and remained stuck to it, "failed" the test. Those that managed to free themselves "passed." On that particular night, the most abundant insects were beetles, lacewings, hemipterans, and moths. Only the last seemed qualified to pass.

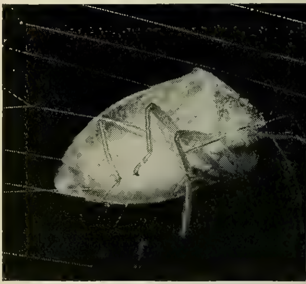
Moths, like their relatives the butterflies, have wings and bodies densely covered with tiny scales (*see photograph, page 30, top*). It is this outer coating that enables them to escape from the spider's trap. Whenever a moth collides with a web and escapes, the particular viscid threads that bear the impact are left conspicuously laden with scales. Because they are only loosely anchored to the moth, the



Droplets of viscid fluid are evenly spaced along isolated thread of web.

Using some of its legs to turn prey, spider, *right*, wraps insect in silk.

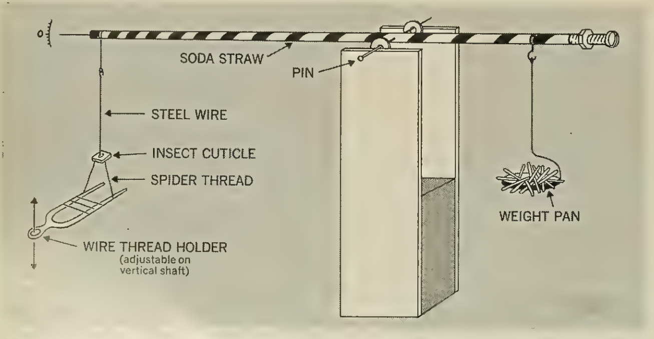
Horizontal threads holding stink bug, *below*, are coated with adhesive.



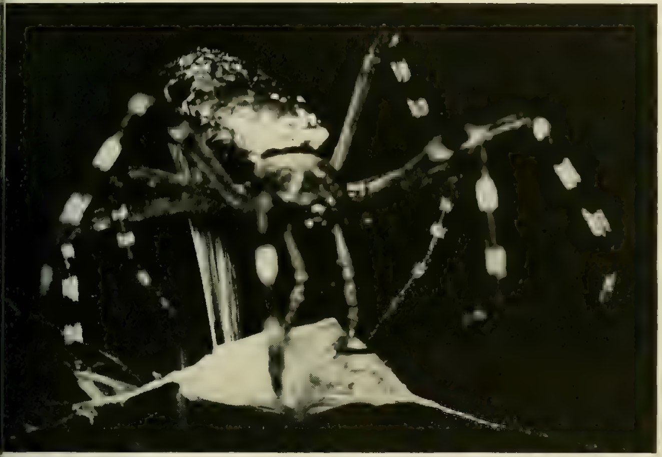
scales are simply torn away by the adhesive threads when the moth strikes the web or during the brief ensuing struggle. (Although scales do not regrow, they are dense enough to allow moths to have several encounters with webs.) Once coated with scales, the threads are no longer adhesive, and the moth is free to fly away. There could be no question that the sort of "web collisions" that we induced artificially with light-attracted moths also occur under truly natural conditions. Scale-covered patches of web—or "moth scars" as we chose to call them—could commonly be seen on any orb web, except, of course, on those most recently spun.

Since defense mechanisms are rarely infallible, it should come as no surprise that some moths do succumb to the spiders. Judging from our own observations, larger moths are less apt to escape than are smaller ones. The latter may simply brush against a thread or two as they fly through the web. Larger moths may not fit the mesh, and are hence more likely to be detained: fluttering violently, but without ever really getting firmly stuck, they "glide" along the orb, leaving behind them a glistening trail of scale-covered threads. In this struggle the spider may have time to make its catch. The successful moth is the one that reverses its direction of flight immediately after impact and essentially bounces off the web like a ball from a tennis racket, or the one that lands near the margin of the orb and glides off without delay.

Since we wished to give some sort of quantitative expression to these findings, we devised a simple technique by which the strength of the adhesive bond between viscid thread and the cuticular surface of an insect could be measured. We were interested primarily in comparison of web adhesion to various types of cuticle, and our aim was, therefore, to obtain a *relative* rather than *absolute* measure of this parameter. The apparatus used (*see diagram below*) was adequate for the purpose. In essence, it consisted of a modified "soda-straw balance," a crude but surprisingly sensitive instrument, sometimes used as a teaching device in elementary schools. One arm of the balance bore a detachable wire hook, to the looped end of which was glued a small square (2 by 2 mm.) of insect cuticle. The cuticle was brought in contact with a single strand of spider thread, held across the prongs of an appropriate wire holder. Small weights were then added, one at a time, to a pan at the opposite arm of the balance, up to the point at which the thread abruptly detached from the cuticle. The load on the pan at the point of detachment was used as a measure of the adhesive strength of the particular cuticle being tested. The procedure was actually somewhat more complicated than described here, since it was necessary that the arms of the balance be maintained level throughout the operation. This was accomplished by moving the wire holder downward along the vertical shaft that held it (the shaft is not shown in the drawing) in such a way as to compensate precisely for the elastic stretching forced on the thread by the



Modified "soda-straw balance," which is a simple teaching device, was used to make comparisons of web adhesion to the various types of insect cuticles.



growing load of weights on the pan.

A variety of insects were tested, using squares of cuticle that had been clipped from their wings (wings were especially suitable because they provided the sort of flat pieces of cuticle that were ideal for testing). One group of insects had "naked" wings—that is, they lacked a coating of scales or other detachable outgrowths. Among these were dragonflies, grasshoppers, hemipterans, flies, and wasps. The other group had "coated" wings, and it included, besides the scale-bearing moths, representatives of a lesser known but nevertheless very common group of nocturnal insects, the Trichoptera, or caddisflies, which have a covering of loose hairs.

The naked wings adhered to the thread most tenaciously, with an adhesive strength that on the average was three times higher than that binding the coated wings. Also, as anticipated, detachment in the case of the coated wings invariably involved a tearing away of the scales or hairs to which the viscid thread had become fastened. As a control, we tested the cuticles of moths and caddisflies from which the coating of scales or hairs had been thoroughly removed beforehand by stroking with a fine brush. Such artificially denuded cuticles adhered as tightly as did those cuticles that were normally naked. Although it remains to be seen whether living caddisflies, like moths, can actually escape from webs, it seems clear from these results that they at least possess the potential to do so.

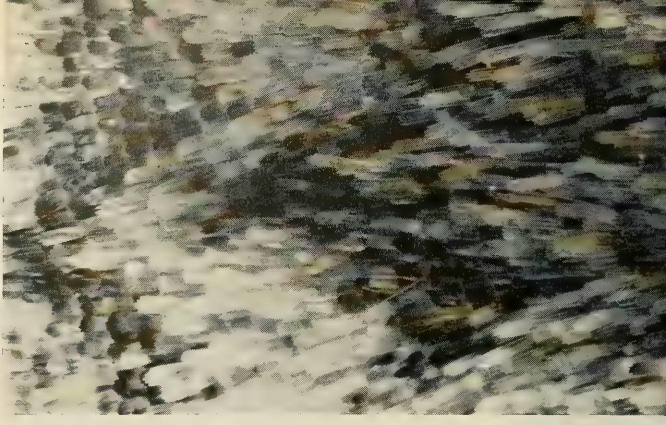
There exist certain insects whose wings and bodies have a flaky or powdery covering, usually white in color, and supposedly of wax. Among them are the whiteflies, which belong to the hemipteran family Aleurodidae. These tiny animals, which may not measure over a millimeter in their largest dimension, were too small to be tested by our techniques. Still, it could be shown that their outer coating might also serve in defense. When individual whiteflies were held in forceps and brushed against a spider thread, they did not stick at all. Subsequent examination of the thread showed it to be densely laden with the "waxy" powder.

In conclusion, it seems patently clear that the possession of a coating of detachable and partly dispensable structures is a distinct defensive asset to any flying insect. This should not be taken to imply that a decreased vulnerability to spiders is the only adaptive advantage to be derived from such a coating. The scales of moths, as well as the hairs of caddisflies, might well have evolved primarily in fulfillment of certain aerodynamic needs. But orb-weaving spiders are an ever-present hazard to any insect on the wing, and on this basis alone cannot be totally absolved from having influenced the evolutionary acquisition or refinement of these integumental outgrowths.

A question that inevitably arises is whether there are predators other than spiders against which the defensive maneuver of shedding scales or similar structures might also be effective. Certain moths are so densely covered with scales that they actually emit a cloud of them when they are caught and handled. Might there not be mammals or even birds on which such a flurry of powder would have a repellent effect? The scales might contaminate the eyes, or be inhaled into sensitive respiratory passages, and by causing appropriate irritation could conceivably lead the predator to an eventual avoidance of such insects.

Under some circumstances, scales might also have a startling or distracting effect. I once observed a kitten chasing insects that had gathered at a lamp at night. In characteristic fashion, it "played" with the insects, trapping them under its front paws, then releasing them briefly, then trapping them again, and so forth. When a moth was captured in this way, it would often shed a massive number of scales, and the kitten, distracted by the cloud of dust that seemed to emanate from its prey, would momentarily shift its attention away from the prey itself. During that instant the moth sometimes made its escape.

ANYONE who has tried to grasp a live moth by the wings knows that he stands a fair chance of losing it. Thanks to the scales—which act like lubricating flakes of powdered graphite—the wings are slippery and difficult to hold. This may again have defensive implications. Insectivorous monkeys usually catch their prey by hand, and one may well imagine that moths occasionally slip from their grasp. Of course, monkeys might learn to overcome this difficulty by refining their attack behavior, but not all predators are as intelligent, and some might lose their moths as a matter of routine.

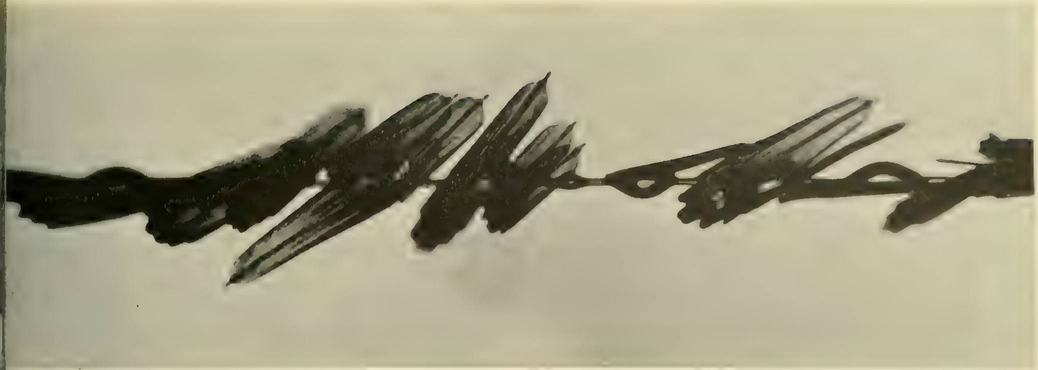


**MOTH WINGS are densely covered with a coating of minute scales, as seen in magnification, *above*, and arranged in patterns like shingles on a roof.**

Insects other than the moth may also benefit from the possession of a slippery coating of scales, and in two separate instances this has actually been demonstrated. There exist certain primitive wingless insects, comprising the order Thysanura, whose bodies are characteristically covered with scales. A common household pest, the silverfish, belongs to this group. I recently tested some thysanurans by exposing them to attacks by ants, which are probably among their chief natural enemies. Since they are extraordinarily quick and agile, they usually eluded the ants without being grasped. However, in those few cases in which an ant did make a catch, the thysanuran promptly slipped away. A "mouthful" of scales was all that the ant ever gained from the encounter.

A comparable but more striking example concerns a species of butterfly, *Liphyra brassolis*, from Australia. It is a member of the family Lycaenidae (the blues, coppers, hairstreaks), and like some others of its group, spends part of its life cycle in association with ants. In the case of *Liphyra*, the cater-

**CAUGHT in web of *Argiope florida*, moth has lost a few scales on web.**



**Scales** torn from the wing of a moth cling to the adhesive secretions on a single strand of the web, here greatly magnified, of an orb-weaving spider.

pillar lives in ant nests, and actually preys upon the brood. It eventually pupates in the nest itself, but the newly emerged adult, which is destined to lead the typical free life of a butterfly, must find its way to the outside. While making its exit, it is sometimes assailed by ants, and it is then that the scales, which in this species are especially dense and "fluffy," fulfill their defensive role. According to the observations of A. P. Dodd, vividly recorded in a paper published at the turn of the century, "the loose scales act as a perfect protection, for directly the ants encounter these they are in trouble; they fasten on to their feet and impede their movements, or, if their antennae or mandibles come in contact with any part of the butterfly, the scales adhere thereto, so that the ant is soon in a bad way, and has quite enough to do in attempting to free himself of his encumbrances without taking any further interest in the butterfly, from which he retreats as well as possible." Other observers have since confirmed that the butterfly does indeed win its freedom in this fashion.

Much may yet remain to be learned about this matter of insects, scales, and predators. Perhaps, given a few million years, even flies will have evolved some sort of detachable coating as a means of escaping from flypaper. This is assuming, of course, that in the meantime neither man, fly, nor flypaper will have gone the way of the dodo, the mamo, and the great auk.

**Damaged web** to which scales cling bears evidence of insect's struggle.

# The Ecology of Man

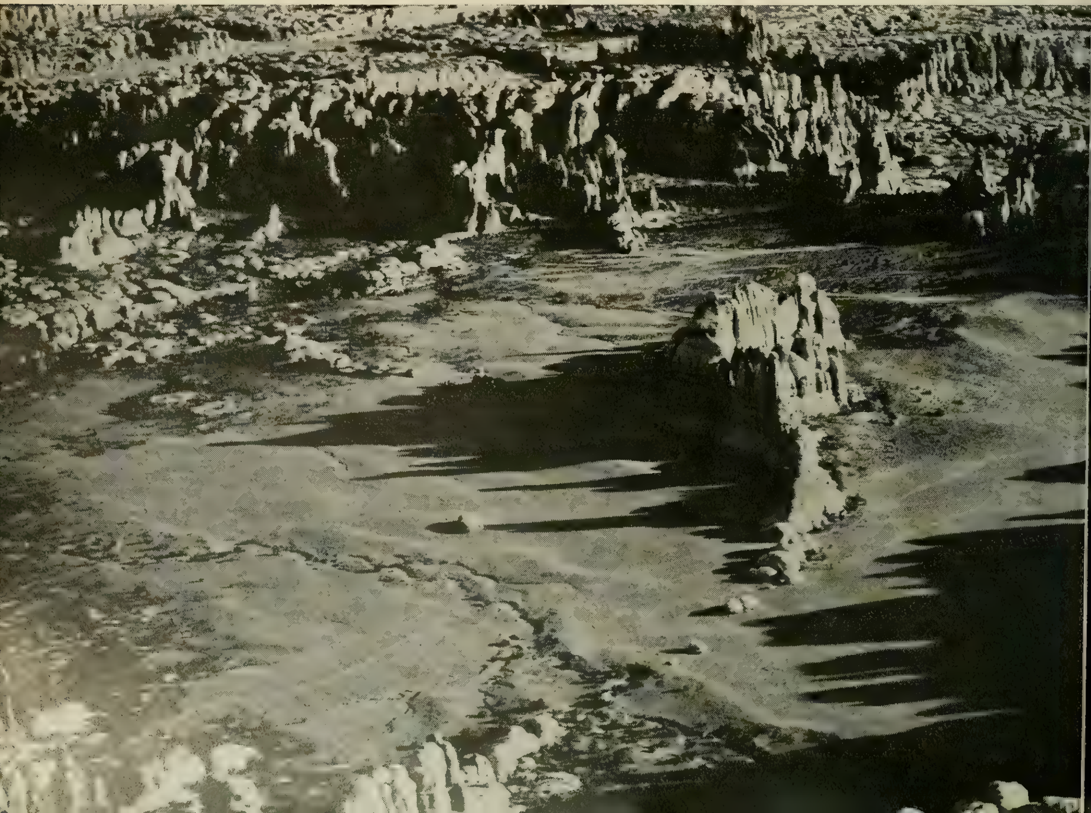
### by STEWART L. UDALL,

One of America's unique contributions to the world is the idea of the national park—the principle of preserving outstanding forest, river, desert, mountain, and shoreline areas for the permanent use and enjoyment of the public. Surprisingly, it began in the latter part of the nineteenth century—a period better known for exploitation than for conservation—and the great expanses of unspoiled wilderness and other scenic areas are tributes to men of vision who saw the fallacy in our national myth of superabundance. Establishment of our national forests and wildlife refuges and particularly our national parks represents an early high-water mark in our emerging land ethic.

Development of the National Park System has been an integral element of the new conservation that President Johnson outlined in his "Message on Natural Beauty." Our parks have evolved from remote and seldom visited nature preserves to world-renowned vacation targets for millions of people—for 111 million of them last year alone. Many departed with a deeper understanding of the meanings of our origins. Many learned new and valuable natural history lessons. Many found new inspiration within themselves. Nearly everyone found enjoyable recreation of one kind or another.

While all visitors are welcome, it is obvious that the staggering demands projected for outdoor recreation could inundate our parks. The alternative is for public and private agencies and individuals to join in a common effort designed to provide adequately for our outdoor needs. Fortunately, such efforts already are getting under way on a number of fronts. Our continent is so vast in its original scenic endowment that the land-use pattern remains flexible. Attractive conservation options await us. Natural beauty is still with us. It can be marred through unwise development. It can be maintained and even restored for scenic and other recreational use and enjoyment. Within the past three and a half years we have exercised our national option to retain natural beauty by adding a half-dozen magnificent and much-needed areas to our national park estate, among them the great Canyonlands National Park.

These new areas demonstrate our emerging national determination to put the welfare of whole regions ahead of the preservation of any single resource. This new con-



# and the Land Ethic

**Secretary of the Interior**

servation is a balanced conservation. It calls for wise planning for the use of our land and the development of our natural resources. It allows material progress and maintenance of a life-giving environment to proceed hand in hand. It helps insure our immediate prosperity and leaves a rich legacy for the years to come.

Today, conservation is vital to every decision that affects our environment. President Johnson has noted that modern technology, which has added much to our lives, can have a darker side. "Its uncontrolled waste products are menacing the world we live in, our enjoyment and our health. The air we breathe, our water, our soil and wildlife are being blighted by the poisons and chemicals which are the by-products of technology and industry. The skeletons of discarded cars litter the countryside. The same society which receives the rewards of technology, must, as a co-operating whole, take responsibility for control," the President said.

"To deal with these new problems will require a new conservation," he has stated. "We must not only protect the countryside and save it from destruction; we must restore what has been destroyed and salvage the beauty and charm of our cities. Our conservation must be not just the classic conservation of protection and development, but a creative conservation of restoration and innovation. Its concern is not with nature alone, but with the total relation between man and the world around him. Its object is not just man's welfare, but the dignity of man's spirit."

The new conservation—balanced conservation—seeks a livable total environment. Preservation of open space, the search for more tasteful architecture and more beautiful cities relates implicitly to our need to save our wilderness, our more inspiring scenery, our areas of greatest park potential. Over the years the National Park Service has pioneered many conservation concepts. It has always been concerned with beauty, both the many uses of beauty and the beauty of constructive use. Its concern has embraced our natural resources, man and his outdoor needs, the past and the present.

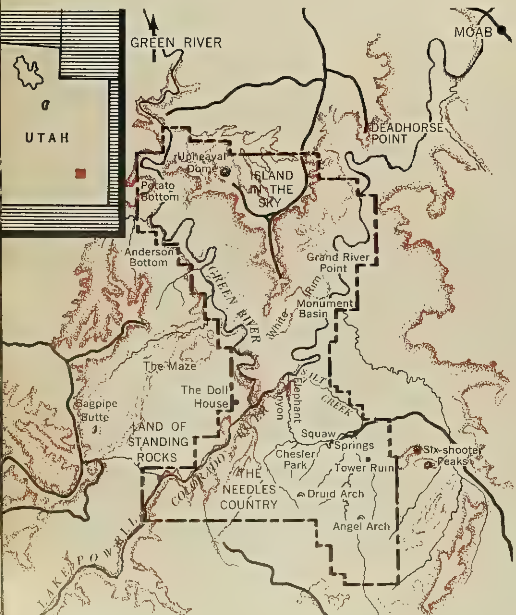
Congress has included natural, historical, and recreational areas within the 206 units of the National Park System. The natural areas date back to 1872 when Yellowstone National Park was established as a "public

*Aerial view shows some 740 acres in Chesler Park, left. Partly filled slot at right in Druid Arch, above, is 120 feet high.*

park or pleasuring ground for the benefit and enjoyment of the people." Even earlier, in 1864, the Yosemite Valley and the Mariposa Grove of Big Trees were ceded to the state of California. Dedicated "for public use, resort and recreation," together they became the nation's first state park.

Two other significant developments in our federal parks expansion came in 1906. One was the establishment of Mesa Verde National Park to protect its notable prehistoric cliff dwellings. The other was passage of the Antiquities Act, signed by President Theodore Roosevelt. This act gave the President authority to preserve by Executive proclamation "national monuments," including historic landmarks, historic and prehistoric structures, and other objects of historic or scientific interest already in federal ownership. This legal machinery enabled Theodore Roosevelt and other Presidents to act with dispatch to preserve such diverse areas as the Grand Canyon, Petrified Forest, Saguaro, and the Organ Pipe Cactus. Later, Congress authorized the preservation of significant historic areas, culminating in the broad charter for historic preservation set forth in the Historic Sites Act of 1935.

On August 25, 1916, the National Park Service was created. Congress gave it a broad charter to "promote and regulate the use of Federal areas known as national parks, monuments and reservations by such means and measures . . . to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations."



*Broken line encloses the 257,640 acres of Canyonlands, located in area of many other national park units.*

Thus, while the National Park Service is chartered to manage public lands of merit, it is equally chartered to provide for the enjoyment of the people who visit those lands. More than 95 per cent of our national parklands are still in their primitive, natural state. Consequently, all park managers face the dilemma of striking a balance between preservation and use. Within our park concept there can be no question of locking up the wilderness. The wilderness proper serves all park visitors. Those who penetrate it gain its fullest rewards. More often than not the undeveloped park wilderness beyond the roads furnishes the setting and the background that make each national park a unique and outstanding attraction.

This will unquestionably be true in the nation's newest national park, Canyonlands, at the confluence of the Green and Colorado rivers in southeastern Utah. The park itself contains 257,640 acres, a small but scenically striking segment of red rock canyon country that contains the most varied and spectacular examples of geologic erosion in the world. This region in southern Utah and northern Arizona features more national park units than any comparable area in the United States. It encompasses Grand Canyon, Mesa Verde, Zion, Bryce, and Canyonlands National Parks, the projected Rainbow Bridge and Capitol Reef National Parks, eleven National Monuments, and Lake Powell, perhaps the most beautiful man-made lake on this planet.

In Canyonlands, the park visitor will discover arches, needles, spires and standing rocks, broad plains, bold mesas and crenelated buttes, roaring rapids and placid reaches, sandbars, level bottomlands, and tributary canyons. This is the scenery of geologic erosion, and the master pattern is very clear. The great rivers have done their work well. Intermittent tributary streams, wind, rain, and frost have chiseled the details. And the varying resistances of the rock layers and of their joints and faults have controlled the visible results. With lively and vivid imagination, man has fastened names on these erosional remnants. He has delineated Island in the Sky, Land of Standing Rocks, Elephant Canyon, Devils Lane, Six-shooter Peaks, The Doll House, Lands End, Happy Canyon, The Golden Stairs, Bagpipe Butte, Tapestry Slab, and Potato Bottom.

Canyonlands National Park is only a small portion of the canyonlands that C. Gregory Crampton writes about so perceptively in *Standing Up Country*—a title derived from a wry old mountaineer who said, "There is as much country standing up as there is laying down."

Crampton's comparison between the canyonlands of Utah and the Grand Canyon of Arizona helps put the new park in perspective. The opposite rims of the Grand Canyon, he observes, stand ten miles apart. But the opposite sides of canyon country in Utah are one hundred

*The Doll House lies west of the confluence of the Green and Colorado rivers, on the border of Canyonlands.*

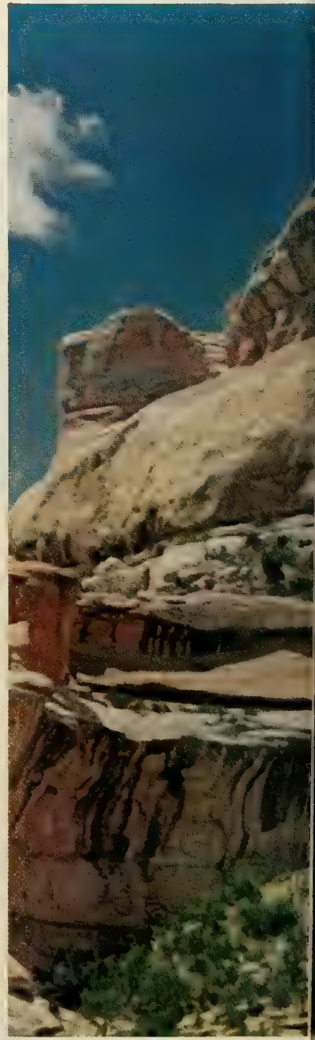
# The New Conservation

miles apart. I can testify personally that they are a hundred miles of grueling canyons, mesas, buttes, reefs, with only here and there a level space.

Early in 1961, after a reconnaissance flight over the region, I requested the National Park Service to update its studies of the park potential of this remote and rugged country. In July of that year, Secretary of Agriculture Orville L. Freeman, Utah's Senator Frank E. Moss and Governor George D. Clyde, two Utah Congressmen, my

*Fin, left, is in Monument Basin. Some of these forms are as high as Washington Monument.*

*Partially filled arch, at right, is in southeast part of park near Salt Creek and the boundary.*

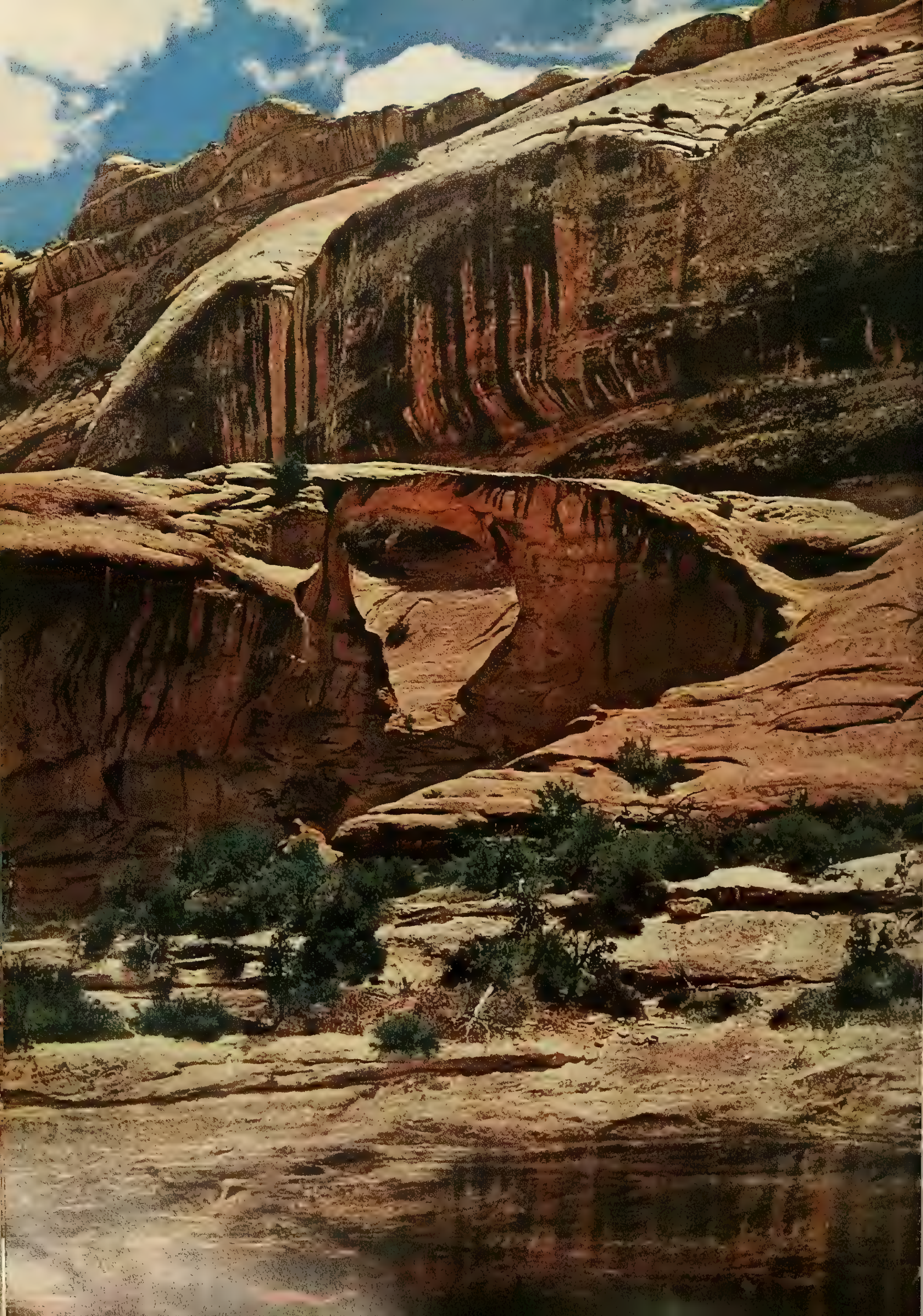


*Indian paint-brush, below, clings to rocks at Grand River Point on tongue of Island in the Sky.*

family, and I made a four-day field inspection of the area. We explored the innermost corners of Canyonlands by jeep, helicopter, boat, horseback, and on foot. A float trip down the Colorado River's deep gorge from Moab, Utah, to its confluence with the Green and then for a distance up the Green gave us a look from the bottom up at Canyonlands' towering red erosional wonders. Most of the area we saw west of the Green River was excluded by Congressional compromise from the final boundaries of the new park. From the bottomlands we flew by helicopter to the Island in the Sky and steered a jeep down to Grand River Point and Upheaval Dome. Then to reach Deadhorse Point State Park (now outside Canyonlands boundaries), we negotiated The Neck, a 640-acre link between two scenic escarpments, just wide enough for a breathtaking road, with a 2,000-foot drop on either side. Again by helicopter, we flew to The Needles and hiked to Elephant Canyon to view the recently discovered Druid Arch.

In addition to the usual views of Canyonlands—from the heights and from the bottom up—I had a special vantage point through the eyes of my three children who accompanied me. Seeing their excitement and awe, I was convinced that this had to be saved for the future.

In August, shortly after our successful reconnaissance, Senator Moss introduced legislation to establish Canyon-



lands. Like Yellowstone, Grand Canyon, Sequoia, Glacier, and Yosemite, the Canyonlands area was already part of the public domain before it was proposed as a national park.

Concurrently a study undertaken by the University of Utah in co-operation with the National Park Service concluded that the Canyonlands area could contribute more to the economy of the state of Utah as a national park than in any other use. Even so, controversy developed over how much area to include in the park and what rights to reserve for mining, prospecting, and grazing. The Governor of Utah made it clear from the start that he was opposed to park status that would, as he put it, "lock up" the resources and "damage" his state's future economy.

In lieu of the 300,000 acres that Senator Moss proposed, Governor Clyde argued for a much smaller park, and at one point Utah's senior Senator Wallace F. Bennett proposed that the park include only three small core areas. These proposals were unacceptable, and a running dispute over boundaries and mining values continued for three years. Ultimately, a compromise was reached, and the boundaries of the original Canyonlands proposal were redrawn to exclude some areas where the mineral potential was greatest. The compromise also provided that cattlemen whose herds had been grazing within the area could "phase out" their operations within the park boundaries over a ten-year period.

Public Law 88-590, establishing Canyonlands National Park, was signed by President Johnson on September 12, 1964.

The problem of providing access roads, trails, and visitor centers while preserving wilderness is not as difficult in Canyonlands as it is in most national parks. Here careful development can allow visitors into the heart of the park in relative comfort without disturbing natural values, and still keep the wilderness areas accessible only by foot, boat, or horseback. Development plans for Canyonlands propose to take full advantage of three distinct levels from which the park can be viewed. Bates Wilson, Superintendent of the new park, calls Canyonlands a vast theater. Grand River Point and Island in the Sky are the balcony; White Rim, The Needles, and The Doll House are the mezzanine; and the river bottoms and gorges are orchestra locations.

"Dry camps," to which visitors must carry their own drinking water, are available throughout the park. Salt Creek in The Needles Country provides water for travelers on horseback. For the present, overnight accommodations are expected to be provided by motels and lodges outside the park. Tourists need four-wheel-drive vehicles to negotiate much of Canyonlands. Unpaved but passable approach roads allow ordinary passenger cars to go as far as Grand River Point in the Island in the Sky, or to Squaw Spring in The Needles area. In the land between the rivers, the Island in the Sky will be the primary visitor-use area. Roads, overlooks, and various interpretive devices, including a visitor center, self-guiding trails, and a campground are planned. The White Rim road skirting the lofty Island in the Sky will remain a trail for four-wheel-drive automobiles.

The Canyonlands management expects to complete 26 miles of approach and park roads by the fall of 1965. These will permit passenger cars to reach Chesler Park and Virginia Park in The Needles Country, and to approach within hiking distance of such remarkable geological features as Elephant Canyon, Druid Arch, Tower Ruin, and Angel Arch.

Ultimately, there will be hard-surfaced roads, but it will be a number of years before Canyonlands will be as accessible as other parks nearby. Even when the roads are built, they will not be allowed to dominate the landscape through which they pass. Where rivers and canyons divide major segments, access to the separate areas will be from outside roads—not via connecting bridges and roads within the park, which would scar the landscape. Canyonlands will always remain a wilderness park, requiring a horse, a mule, a boat, a good pair of legs, and a backpack, and once in a while a four-wheel-drive car.

Canyonlands' rivers will provide visitors a wide range of recreational opportunities. Both the Green and the Colorado rivers are navigable, and this impressive country should be seen from the bottom up. A few river runners will continue to challenge the rapids of Cataract Canyon down to the impounded waters of Lake Powell. Most visitors will be content with floating the Colorado from Moab to Spanish Bottom, then up the Green River via Anderson Bottom to the town of Green River, Utah.

As our population continues to soar and as places of retreat and contemplation continue to diminish, Canyonlands and the other new areas just authorized by the Congress for our National Park System become more valuable. Every new local, state, or national park area we are able to add to our public estate henceforth will acquire added significance with each new generation.

Even in our present era, leisure is moving rapidly from the fringe to the core of life. It is both fitting and necessary that the legislative and the executive branches of government have joined in a massive effort to provide park and recreational lands sufficient to the needs of the nation. President Johnson aptly referred to the 88th Congress as the "Conservation Congress." Among areas it authorized were Canyonlands, Fire Island National Seashore, Ozark National Scenic Riverways, Lake Mead National Recreation Area, and, with the Canadian Parliament, the Roosevelt Campobello International Park.

These and other actions followed the fine precedent set earlier when the 87th Congress, in authorizing Cape Cod National Seashore, also authorized, for the first time, appropriations of the necessary funds to purchase the required lands. This departure from traditional methods of acquiring lands for National Park System areas—from state and private donors, or from the public domain—was in response to the tremendous surge of interest in outdoor recreation this nation has witnessed since World War II.

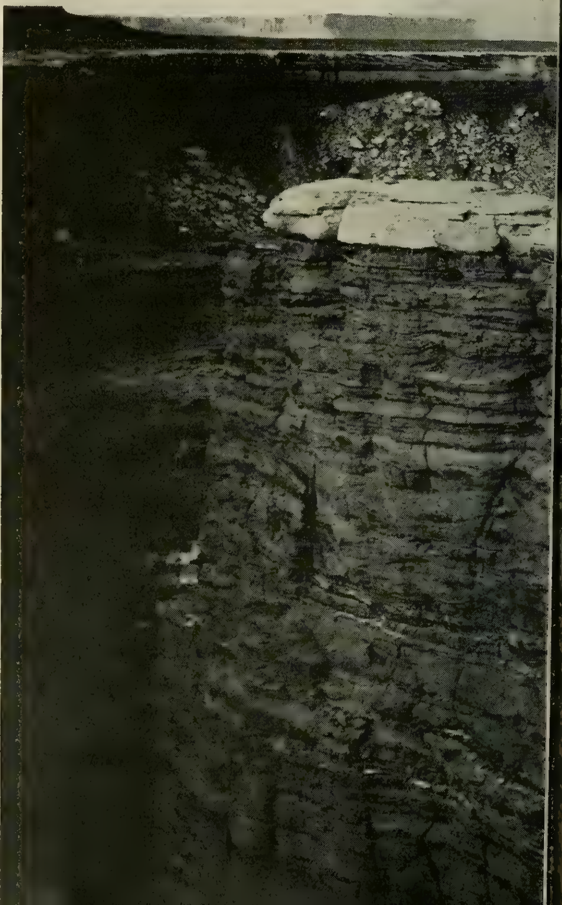
In one of its most notable actions, the 88th Congress

*This arch, below massive surrounding formations, is near upper Salt Creek, and was not discovered until 1962.*

provided us with a new and powerful conservation instrument. This is the Land and Water Conservation Fund. It authorizes grants-in-aid to the states on a matching basis for planning, acquiring, and developing needed outdoor recreation areas, and provides funds for certain federal recreation needs. Estimates are that as much as 200 million dollars may be available for distribution from the Fund in average years—60 per cent to the states, the remainder for federal needs. The Fund became effective January 1, 1965, and will continue for twenty-five years. Its revenues will come from nominal admission and user fees at designated federal recreation areas, from the existing motorboat fuels tax, from net proceeds from the sale of federal surplus real property, and from repayable advance appropriations beginning in the third year. New this year will be a seven-dollar annual Recreation/Conservation Sticker that will admit an automobile and all its occupants to any federal recreation area designated and posted under the Land and Water Conservation Fund Act. The sticker, designed for attachment to the front bumper of an automobile, is now on sale in or near federal recreation areas where it is required. Although the sticker is a real bargain for families going in and out of several national parks, forests, wildlife refuges, or other recreation areas, purchase is optional. Single-entry fees and weekly fees may be paid by those who prefer to do so. The conservation sticker will appeal to many who may never visit federal recreation areas, since it will help provide a pay-as-you-go means of meeting our current outdoor recreation needs and those for the future.

In this program and others lie much hope that our national effort in conservation is quickening. Yet, with all our conservation successes, President Johnson has found it necessary to warn us that it is a "sad and sobering fact that we are losing the battle to keep America beautiful." If we are to live in a more

*Lone yucca blooming on White Rim emphasizes space and grandeur encompassed in our newest park.*

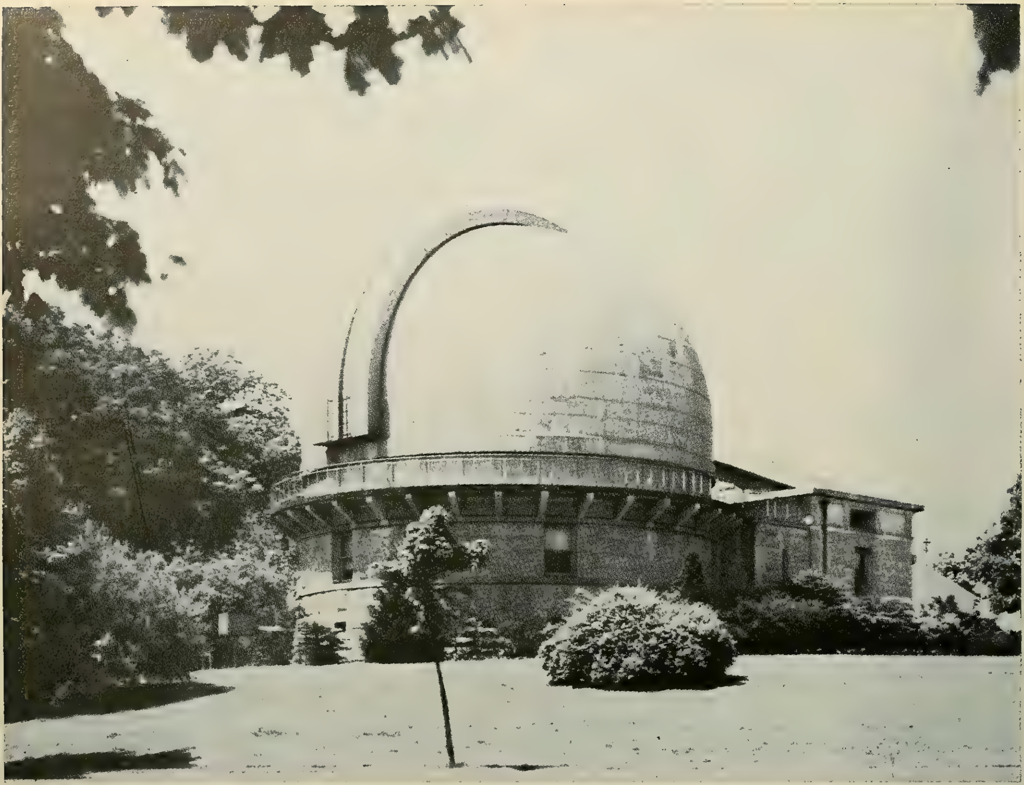


*Also taken from White Rim, this picture looks down on the red rock at the head of Monument Basin.*

beautiful America, we will need more recreation lands, particularly near the heavy population concentrations on the east and west coasts. The President has asked the Congress to take favorable action on a number of proposed additions to the National Park System. For the most part, these are intended to serve the large metropolitan areas where opportunity for outdoor recreation is in increasingly perilous supply.

At the moment we still enjoy the opportunity to provide for some of our recreational needs by setting aside segments of a number of wild rivers that remain free-flowing and unspoiled. These exist throughout the nation, although their number and quality are diminishing rapidly under the pressures of civilization. The President has recently sent to the Congress a bill to establish a National Wild Rivers System. Such a system would protect and maintain certain streams or portions of streams in their free-flowing state—for canoeing, fishing, back-country camping, and other outdoor recreation opportunities that can best be enjoyed in a primitive environment. We have dedicated rivers to commerce, flood control, industrial and municipal water supply, waste disposal, irrigation, power, and many other uses. It seems reasonable that we dedicate at least a few to public enjoyment.

The American people have inherited what Robert Frost once called the "best cut of continent for active men." Rugged coast, gentle bayou, fertile plain, and timbered slopes have nurtured our institutions and shaped our national character. We cannot afford an America where expedience tramples upon aesthetics, where development decisions are made with an eye only to the present. Preserving the scenic and scientific grandeur of this nation is not a challenge for the federal government alone. It is a crusade in which we all must join. We can have both abundance and natural beauty in our environment if we develop a land conscience that will inspire daily acts of stewardship to make America a more pleasant and a more productive land.



**Naval Observatory** in Washington was founded in 1842.

# SKY REPORTER

## Observatory is the U. S. Navy's oldest official scientific agency

By Thomas D. Nicholson

About three and a half million persons annually visit the major planetariums in the United States. For most of them, a planetarium is the only kind of astronomical institution they will ever enter. Many have a misconception concerning what a planetarium is and how it differs from an astronomical observatory.

Fundamentally, a planetarium is a museum or an educational institution devoted to lecturing, teaching, and exhibitions in astronomy. Its principal facility for accomplishing this is a theater where a projected replica of the sky can be shown and used for demonstration purposes.

An observatory, on the other hand, is primarily a research institution. Its facilities—including telescopes of many kinds—and staff are selected to observe and to acquire knowledge about the universe through research. Many observatories are affiliated with the astronomy or physics departments of colleges and universities. Others have tours for visitors in their programs.

There are many observatories in the United States that are, at times, open to the public, and that make arrangements for people to look at the sky through telescopes. During the next few months we shall describe certain of the observatories, their histories, facilities, and research programs. We shall begin, this month, with a description of the United States Naval Observatory at Washington, D.C.

In a sense, the Naval Observatory may be considered the official astronomical observatory of the United States. Its purpose is to provide fundamental data and standards derived from astronomical observations. With respect to time, the Observatory furnishes the accurate standard time used by everyone in the country, including radio and television stations, navigators in naval and commercial vessels, scientists, space technicians, or anyone requiring precise measurements of time. Almost all of the data that come to our attention, such as forthcoming eclipses; the times of sunrise, sunset, moonrise, and moonset; the duration of twilight; and the advent of the seasons, are derived from tables given by, and observations made at, the Observatory (as are the data in the "Sky Reporter" calendar).

The Naval Observatory grew out of two needs that were felt early in the history of the United States. Once the site of the federal capital had been chosen, the government expressed the desire for constructing an observatory in order to establish a meridian there and through its use to publish an almanac for use by surveyors and navigators. Had it not been for the disruption caused by the war with England, the proposed observatory might have been established at Washington as early as 1814.

The Department of the Navy recognized the vital need for supplying ships with information, charts, and instruments for navigation, including precise standards of time. To that end, in 1830, the Navy established the Depot of Charts and Instruments at Washington where, in 1838, a small observatory was built for the standardization and regulation of time.

On August 18, 1842, President John Tyler signed an act authorizing the founding of a Naval Observatory on public lands in the District of Columbia. In 1844, the observatory and staff of the Navy Depot of Charts moved to a 19-acre site not far from where the Lincoln Memorial now stands, and in 1846 it was authorized to make the results of astronomical observations available for the preparation of a national almanac and to make use of its findings as contributions to astronomical science.

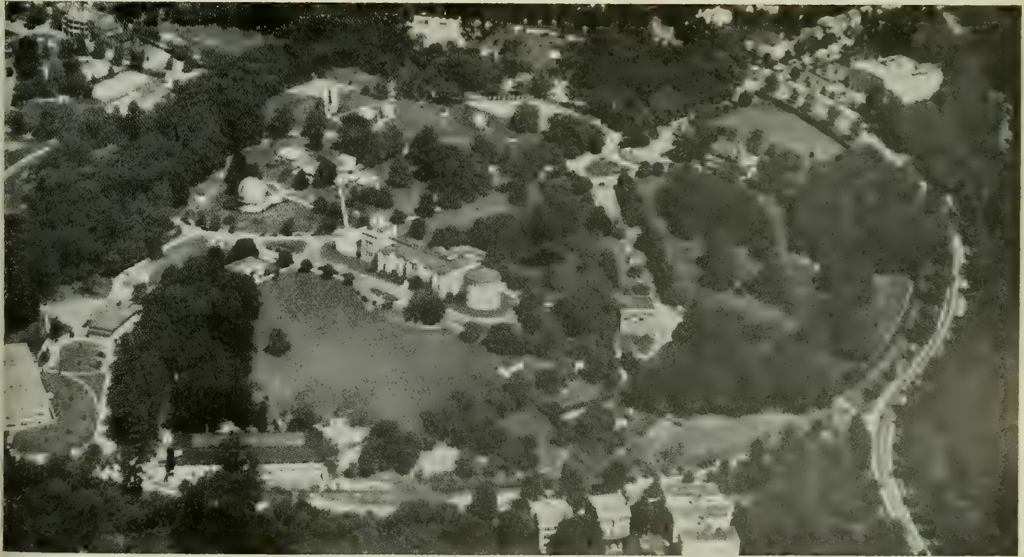
As the Observatory grew, so did the federal capital. Very soon the growth of the city made it difficult, if not impossible, to make astronomical observations at the original location, and it became apparent that a new site would have to be found. In 1893 the Observatory was moved farther out, to 34th Street and Massachusetts Avenue.

Traditionally, the Superintendent of the Naval Observatory has been a senior officer appointed to that position by the U. S. Navy. The scientific program, however, is under a Scientific Director, who is assisted by a large permanent and visiting staff. Under him, work of the Observatory is supervised in several divisions. The Nautical Almanac office is responsible for preparing and publishing the tables of astronomical data used by navigators, engineers, and astronomers, such as *The American Ephemeris and Nautical Almanac*, the *Air Almanac*, special volumes used by surveyors, and circulars giving the circumstances of forthcoming eclipses. The Nautical Almanac office also contributes data to other basic astronomical references, such as the annual *Apparent Places of Fundamental Stars.*

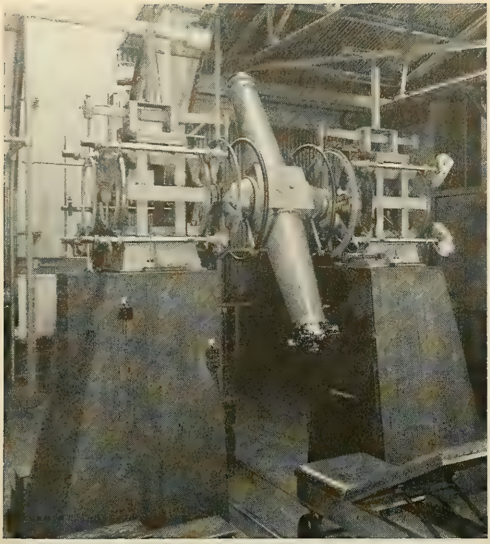
THE Time Service Division of the Observatory has a continuing program of measuring accurate time from astronomical observations. From the master clock room at the Observatory, standards of time and frequency are supplied to broadcasting stations operated by the U.S. Navy, and observations are made of the times and frequencies broadcast by other agencies and by foreign time services.

Observations of the positions of the sun, moon, and planets, and of many thousands of reference stars are continually being made under the supervision of the Six-Inch Transit Circle Division and the Seven-Inch Transit Circle Division. These observations are used to determine the fundamental framework of reference lines on the sky that act as a guide for geodetic measurements of the earth and for the location of celestial bodies.

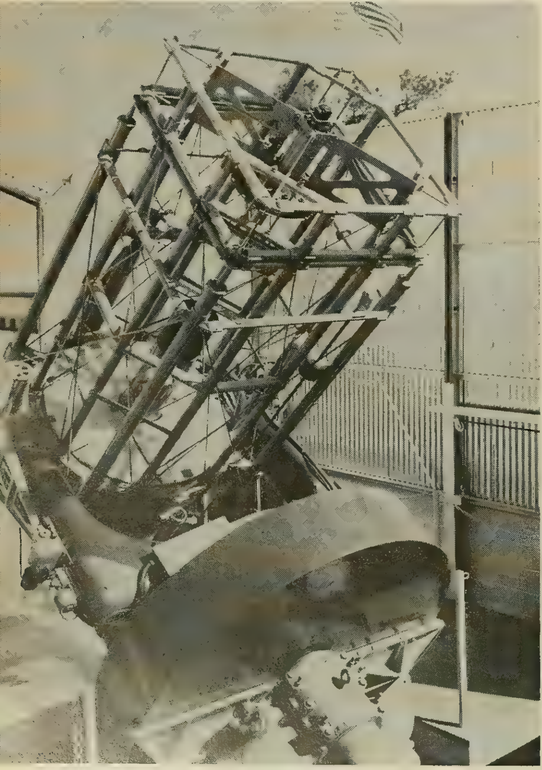
The Astrometry and Astrophysics Division of the Observatory carries out an intensive program of astronomical research. The principal instruments used by this division are a 40-inch reflector and a 60-inch reflector located at the Flagstaff Station of the Naval Observatory, Flagstaff, Arizona. The 40-inch reflector was originally constructed



**For almost fifty years the Observatory remained north of where the Lincoln Memorial now stands. In 1893 it was moved to Naval Observatory Circle, at 34th Street and Massachusetts Avenue, NW., because of viewing conditions.**



**Specially designed telescope,** a six-inch transit circle, is for use in observing the passage of stars across the meridian.



Forty-inch reflector at the Flagstaff, Arizona, station of the Observatory is used mainly for astrophysical research.

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Dr. Nicholson, the regular author of this column, is also Chairman of The American Museum-Hayden Planetarium.

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at Washington, but it was moved to Arizona about a decade ago because of the deteriorating atmospheric conditions in and about Washington. Designed for astrophysical work, the telescope is used to observe the brightness, color, and spectral type of stars. The largest telescope of the Naval Observatory, the 60-inch reflector, was dedicated at Flagstaff on June 19, 1964. Its objective mirror was produced from the largest quartz disk ever manufactured, and although not the largest, its mirror may well have the most accurate surface among the large telescopes of the world. This telescope was designed for astrometric work (accurate measurements of the positions and motions of faint stars by photographic methods). It will be devoted primarily to observations from which the distances of faint stars can be accurately determined. The distances to these stars must be known before their fundamental properties can be studied.

The largest telescope on the Observatory grounds in Washington is the famous 26-inch refractor, first placed in service in 1873. It was with this telescope that Asaph Hall, in 1877, discovered the two small satellites of Mars. Completely modernized in 1960, it is still being used actively in the observations of double stars, for the purpose of determining their masses and distances. There are two other moderate-sized refractors at the Observatory—the 12-inch refractor and a 15-inch refractor, the latter being used in recent years for observing and photographing asteroids.

The Observatory facilities also include the two transit telescopes, used for timing and observing the positions of celestial bodies as they cross the meridian of the Observatory; a dual-rate moon camera, for observing the position of the moon among the stars in the measurement of ephemeris time; and a photographic zenith tube, which is used nightly to photograph stars passing near the zenith of the Observatory to determine mean solar time.

THE scientific program of the Observatory actually goes far beyond its own staff and facilities, through participation in astronomical investigations and discussions with many other national and international groups.

The grounds of the Observatory in Washington are open each afternoon during the week. Tours through the grounds and buildings are conducted at 2:00 P.M. daily, Monday through Friday. Many displays and exhibits, in addition to the important facilities of the Observatory, can be seen by the visitors. The oldest official scientific agency of the U.S. Navy, the Naval Observatory is today an institution of which all Americans can well be proud.

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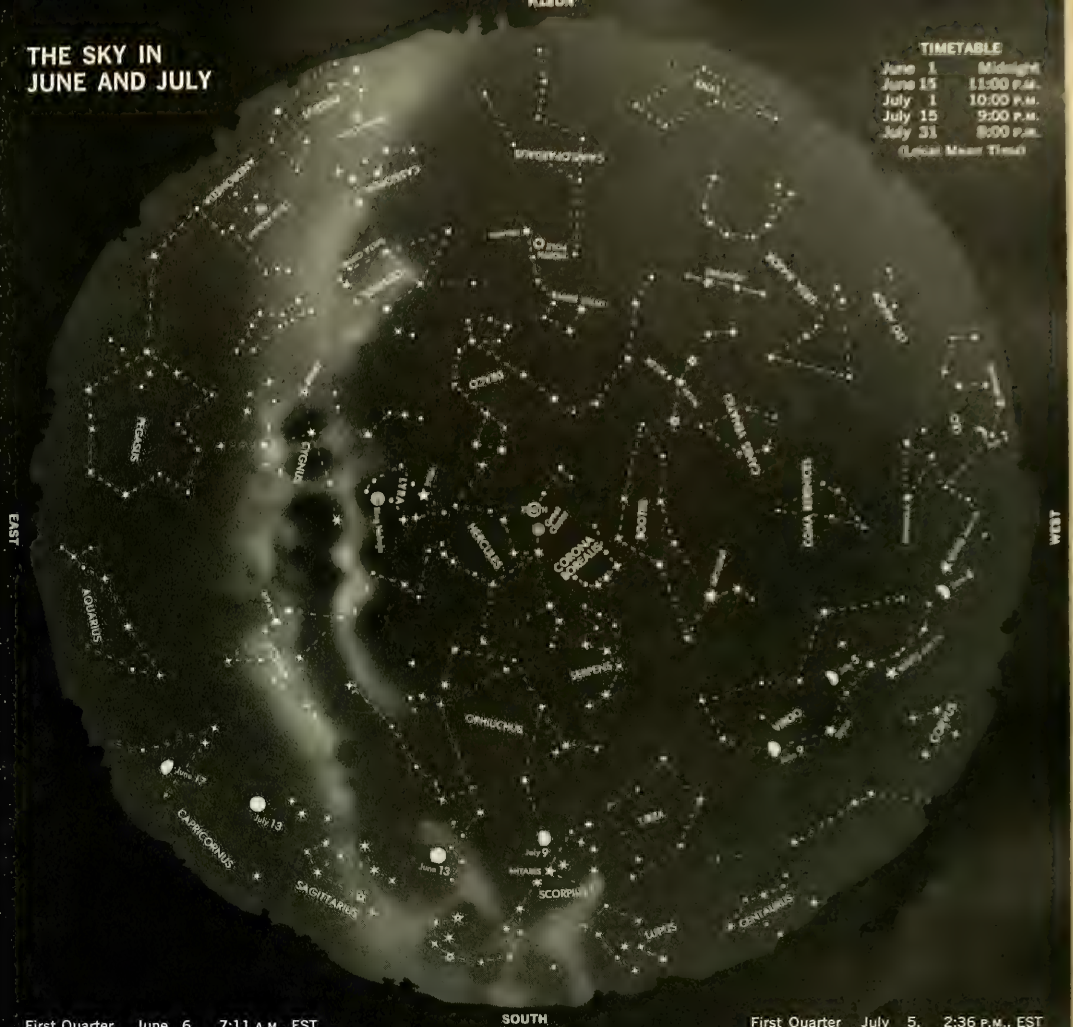
### PARTIAL LUNAR ECLIPSE

During the evening of June 13, 1965, the northern edge of the full moon will pass through the shadow of the earth, and a partial eclipse of the moon will be visible from parts of the earth where the moon is above the horizon, including, generally, the eastern portion of the United States. At maximum eclipse, about 18 per cent of the moon's diameter will be in the shadow of the earth. The timetable is as follows:

| | | |
|---|---|---|
| Moon enters umbra | June 13, | 7:58 P.M., EST |
| Middle of eclipse | June 13, | 8:49 P.M., EST |
| Moon leaves umbra | June 13, | 10:40 P.M., EST |

# THE SKY IN JUNE AND JULY



**TIMETABLE**

| | |
|---|---|
| June 1 | Midnight |
| June 15 | 11:00 P.M. |
| July 1 | 10:00 P.M. |
| July 15 | 9:00 P.M. |
| July 31 | 8:00 P.M. |

(Local Mean Time)

| | | |
|---|---|---|
| First Quarter | June 6, | 7:11 A.M., EST |
| Full Moon | June 13, | 8:59 P.M., EST |
| Last Quarter | June 22, | 12:36 A.M., EST |
| New Moon | June 28, | 11:52 P.M., EST |

| | | |
|---|---|---|
| First Quarter | July 5, | 2:36 P.M., EST |
| Full Moon | July 13, | 12:01 P.M., EST |
| Last Quarter | July 21, | 12:53 P.M., EST |
| New Moon | July 28, | 6:45 A.M., EST |

June 6: Mars is in conjunction with the moon at 11:00 A.M., EST. At sunset Mars is a reddish object about magnitude +0.7, toward the southwest.

June 11: Mercury is in superior conjunction (on the far side of the sun from earth) and enters the evening sky.

June 13: Partial eclipse of moon (see note on page 44).

June 20: Saturn is in conjunction with the moon about 8:00 P.M., EST. After moonrise (about midnight), Saturn is visible to the right (west) of the waning gibbous moon.

June 21: The sun arrives at the summer solstice (its most northerly position over the earth) at 9:56 A.M., EST. On this day, it is overhead at noon on the Tropic of Cancer; summer begins in the Northern Hemisphere.

June 29: Saturn is stationary in right ascension and begins retrograde (westerly) motion.

June 30: Both Mercury (at about 8:00 A.M., EST) and Venus are in conjunction with the moon today. At sunset tonight, with a clear westerly horizon, observers may be able to see the day-and-a-half-old moon, a very slim crescent that follows sundown by about an hour. Venus should be visible as a bright starlike object (magnitude —3.3) just below the moon about 15 minutes after sunset.

July 3: The earth reaches the point in its orbit called aphelion, where it is at its greatest distance from the sun during the year, about 94,454,000 miles. With Venus in the eastern sky on these nights, observers should be able to see Mercury this evening at 8:00 P.M., EST. Mercury and Venus are in such close conjunction that they may be seen as a single object with the unaided eye. But binoculars should separate them easily, with Venus above and the brighter of the two, and Mercury below.

July 18: Mercury is at greatest easterly elongation this evening, and should be easy to find in the western sky, about 3 degrees from Venus for about 45 minutes after sunset.

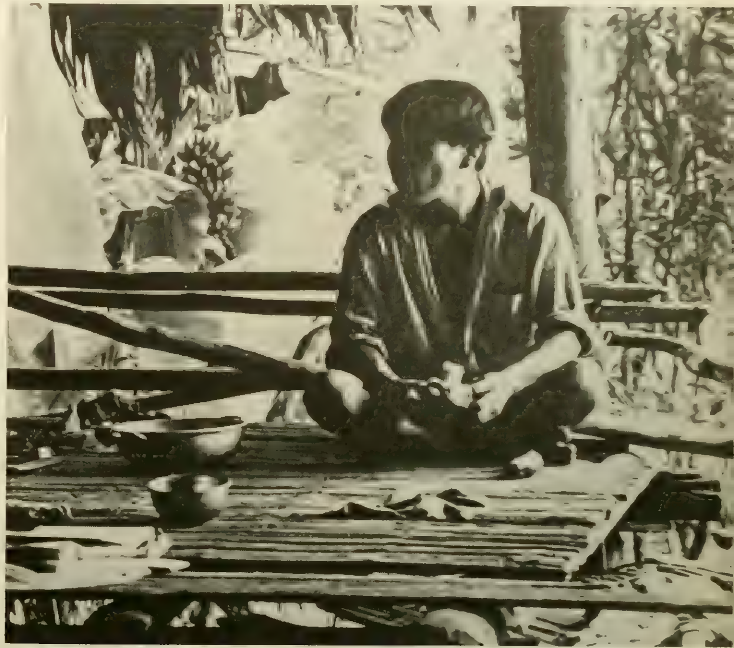
July 25: Jupiter, which disappeared from the evening sky in May, can now be seen as a bright morning star, magnitude —1.6, rising about two hours before the sun. It is in conjunction with the moon at 9:00 A.M., EST.

July 31: Mercury is stationary in right ascension and resumes direct (easterly) motion, bringing it closer to the sun.

# Chocós of the Taparal

## Indians of Colombia face social changes

By J. W. L. Robinson



**Homes are constructed of chontaduro palm on top of tall stilts. There are no interior or exterior walls in huts, and floors are made of split palm trunks.**

Two distinct Indian groups, the Noanamá and the Embera, live in the Colombian rain forests of the Chocó that lie west of the Andes along the Pacific coastline. However, despite their similar material cultures, these tribes speak mutually unintelligible, yet closely related, "Chocó" dialects. Chocó is a loosely defined term referring both to the Indian tribes and to a broad linguistic classification, and is also technically a department of the Republic of Colombia.

This report, which concentrates on a group of the Noanamá who live on the Rio Taparal, a small western tributary of the Rio San Juan, covers part of an ethnological program carried out by the 1962 Cambridge (England) Calima Valley Expedition. We spent nearly four months in Colombia and lived for several weeks among the Noanamá. Calima Valley, for which the expedition was named, is a small valley on the higher slopes of the western chain of the Andes.

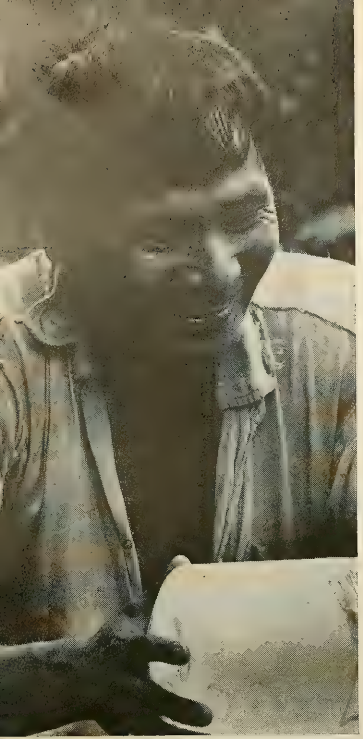
The Chocó Indians do not live in villages, but in scattered houses along the banks of the rivers. This gives rise to a society based on the family rather than on the community. Their homes, or *tambos*, are built of chontaduro palm trunks on top of six-foot stilts. Dried palm leaves, overlapped and lashed to a framework of branches, form the roofs. About half of the roofs are conical, and the rest are rectangular—a design that has been copied from the structures of neighboring Negroes. It is believed that the original Chocó *tambo* had a conical roof surmounted by an earthenware apex—fashioned in the form of a human figure but having apparently no religious significance—to keep out the rain. The conical huts of today maintain similar apexes.

The houses usually have no outside walls—only horizontal bars to prevent the children from falling to the ground. There are no partitions in the house, and the rooms are often built on different levels to separate them. Small stools, used only by the men, comprise the bulk of the furniture. Babies are often left to swing in small hammocks, or even in wooden trays, slung from the roof with string.

**Traditional huts of Noanamá Indians on the Rio Taparal have conical roofs.**

In the kitchen area, a wickerwork fan called a *sopladera* is used to keep the open fire burning, and around the fire are the various appendages of an Indian kitchen—earthenware pots and water jugs and large baskets of maize, sugar cane, bananas, and plantains (a type of cooking banana). The fronds of the roof form an easily accessible storage space, and bows and arrows, lances, and guns are tucked into the thatch. The roof is also the place for keeping carved stirring spoons called *caoingas* and for storing the wooden supports used in making *chicha*, an alcoholic drink. In one house we saw a pump drill that was driven by an unwinding string, rather like a string-projected top, which made perforations in dried gourds so that they could be used as sieves. Each house has a sugar press, which is constructed from two large logs on pivots. The principle is that of an ordinary mangle—one log is wound with a handle. A few metal objects may also be found in the kitchen—usually knives or pots that the Indians have obtained from the Negroes. Nearly every house has its own metal meat mincer. used to grind maize for porridge or *chicha*.

The highest rainfall in the Americas occurs in this area of Colombia—more than three hundred inches annually.



Constanzo, who befriended members of expedition, laughs at plastic bottle.

Women stay near the river, although the men will often visit Buenaventura.

The temperature stays around 85°–90° F. and the humidity seldom falls below 100 per cent. Because of the extreme climate, the Noanamá wear few clothes. The women wrap a piece of cloth around their middles, and the men wear a small loincloth and sometimes a shirt. Personal adornment is carried out with great care, particularly by the men, who keep their festive regalia in a special box hidden in the house behind a pile of pots or baskets. The men often wear earrings, especially when they go visiting. One common type is wooden, and is shaped like a mushroom with a piece of metal hammered over the top. Colombian coins are used to make ornamental rings and pendants, and bracelets and multicolored headresses are made with small Panamanian beads threaded on a piece of fiber string. Sometimes the Indians paint their bodies with vegetable dyes, such as *bija* (*Bixa orellana*) and *jagua* (*Genipa americana*).

The Noanamá are primarily agricultural. They grow their own maize, bananas, sugar cane, manioc, and even rice, some of which they sell in the nearby Negro villages. They are also keen hunters, using either their ancient shotguns or beautifully made bows and arrows. Only one man on the Taparal had a blowgun, which he had obtained from a group of Noanamá on the Docordó, about a three-day journey to the north. Although nearly every household possesses a gun, many of the Indians prefer to hunt with poisoned arrows, and they keep a trophy collection (wild boars' teeth, toucan bills, etc.) in their huts as a mark of prowess. Poison for the arrows comes from a tree they call *paquirachi*, (*Ogcodeia ternstroemiiflora*). The trees are tapped for a short period of time, and the sap is run off and simmered to yield a potent poison—the only specific cardiac poison known to any American Indians. (H. Wassén, the Swedish ethnologist, has described how the Noanamá of the lower San Juan extract a poison from frog glands and use an admixture of this extract and their *paquirachi*. The Indians we visited knew of the frog poison but never used it.)

The Noanamá fish by various means. The most common method is to shine a flashlight into the water at night and spear the fish that are attracted to the light. They trap fish as well—using large, baited baskets from which the fish cannot escape, or in nets of chontaduro palm fiber. One man we saw had a huge harpoon, made in a style the Negroes had designed for deep-sea fishing, which he apparently operated from his small canoe.

Forestry is one form of commerce practiced by the Noanamá. The forests between the rivers are rich in valuable woods, and by agreement with other members of the community each Indian householder is heir to certain tracts of jungle to develop or exploit as he likes. Some areas he uses for cultivation, while others he deforests at appropriate times to augment his income. He may trade timber with neighboring Negroes or may float his balsa logs to the sawmill at Palestina on the lower San Juan.

The Noanamá women spend a considerable time making baskets, many of which are sold in the Negro settlements. Three types of liana are used; they are peeled down to produce the various wickers. Some may be dyed red with a bignoniaceous dye (*Arrabidaea chica*). Potmaking is another occupation of the Noanamá women, but little of this art is carried out on the Rio Taparal.

In an area where communications are exclusively by water, it is not surprising that the Indians are exceedingly skillful navigators. Their canoes are made from large logs of *jigua negro* (*Nectandra* sp.) gouged out with a homemade adz that is constructed from a machete blade. Some men paddle more than three hundred miles to trade with neighboring (and related) tribes in Panama. These men gain considerable prestige in the eyes of their peers by undertaking such a dangerous sea trip.

Noanamá Indians are fine craftsmen in every sphere, but perhaps the carvings centered around their religious beliefs best reveal their talents. Briefly, they believe in an omnipotent god, called Evandama, who lives in the sky and speaks to them through lightning and thunder. Most of their religious ceremonies, however, concern the spirits of their ancestors and of the wild animals of the jungle that are responsible for the fortunes of the community. Each household has a tutelary spirit for assistance and protection, whose representation, carved in balsa, or *chachajo* (*Aniba perutilis*), is kept in the hut in a prominent place. Also guarded most carefully—

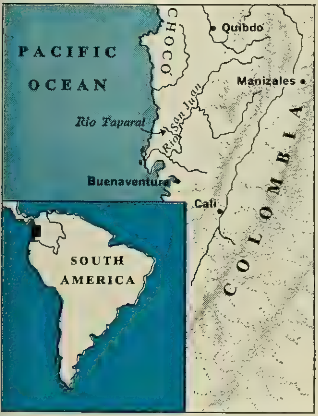
often wrapped up in a clean roll of palm fiber—are their beautiful *bastones tallados*, sticks of hardwood with a figure at one end, that represent individual tutelary spirits (*see photograph, bottom right*). These sticks are carved with the greatest of care, polished, and often smoked over the fire to make them black. They have various uses, and the shaman, or *jaibaná*, of the community owns several. (He also has other carvings, such as small lances, which are made of the same hardwood and are used symbolically to arm a good spirit so that it can defeat an evil spirit that may have caused illness, bad harvest, or lack of success in hunting.) The Indians also love to carve animals out of balsa wood, sometimes for religious reasons and sometimes merely as toys for the children. One of the finest we saw was a representation of a horse and rider that had been carved completely from memory by an old man (*see photograph on page 51*). He probably had seen a horse on one of his rare journeys into Buenaventura, and his stylized representation was magnificent.

The *jaibanás* can be divided into two classes—those who cure diseases primarily with herbal remedies, and those who use hypnotics to have recourse with "spirits." On the Taparal there were two *jaibanás*, Oscar and Gabriel, who were respectively of the first and second type.

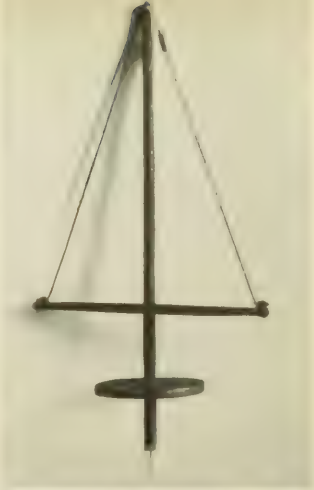
Oscar showed our party his carved balsa boat with its armed crew, in front of which he sat while learning the shamanistic art from an older and wiser *jaibaná*. Gabriel, on the other hand, was a famous healer, and we were lucky to be able to attend one of his healing sessions. His patients were two Negroes from the San Juan area who had already been treated by another Indian *jaibaná* and a Negro doctor. But on hearing of Gabriel's fame, they had come to be healed of a disease that seemed, to us, like arthritis. They were to live in Gabriel's *tambo* for nearly a month, and three curing sessions were to take place. Close friends of Gabriel had been invited to attend. The fee was two hundred pesos for each patient, and it included the cost of the patient's board and lodging.

When we arrived for the first healing session, the two Negroes and their families had gathered. The hut was in darkness, except for a few candles, and a tent of sheets had been erected in one corner where the wife and child of one of the patients could sleep. The Indians' dogs had been shut out, and all bows and arrows were left outside. The occasion was one of appeasing the wild animal spirits that were supposed to have caused the illness, and it was believed that pacification would be simpler if the instruments of hunting were out of the house. When not in use, the ladder up to the house was covered with a plank to prevent the entry of a dog, which, it was believed, might wreck the proceedings. The patients sat on one side of the hut with Gabriel, who was wearing neither a shirt nor any form of paint or adornment for the ceremony.

Constanzo, one of our friends, and Oscar were to act as bearers for the ceremony, and they produced a bottle of *biche*, a strong alcoholic liquor made from distilled sugar ferment. They gave Gabriel a drink from a communal mug, and then passed the mug to all the other men present. In this procedure the bearer pours a draft into the mug and hands it to the drinker, who is expected to down it in one gulp. Gabriel and his two patients then moved to the center of the floor, and the ceremony started as Gabriel rubbed a palm frond on the floor to awaken the spirits. The disease was supposed to have been caused by the malevolent spirits of the frog, the turtle, and the wild pig, which therefore had to be exorcised during the session. The first patient was made to take off his shirt and lie stomach down on a fiber mattress. Some figures, most of which had been carved specially for



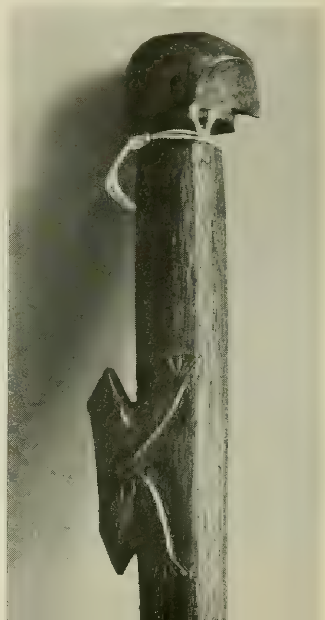
**Noanama** live on Rio Taparal, north of Buenaventura and west of the Andes.



**Pump drill** is driven by a horizontal bar with string winding around shaft.

**Baskets** of peeled liana are made by the women. Wickers may be dyed red.

**Tutelary spirit** for an individual is represented by carved *bastón tallado*.



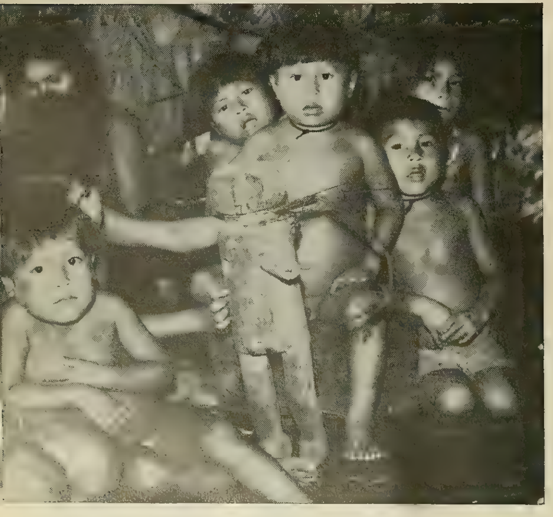
the occasion, were laid by his side. Gabriel spat methodically on his patient's back and rubbed in the spittle. The process was repeated for the second Negro who, being less afflicted, was only massaged in the affected places. Then Gabriel started a monotonous, sonorous incantation and prepared a potion of herbs that he rubbed into those parts of his patients' bodies on which he had spat.

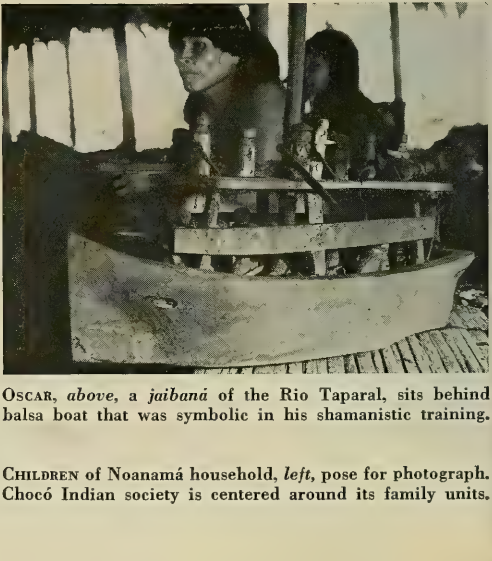
The whole ceremony lasted for about two hours, and between each of the stages, Oscar and Constanzo gave Gabriel a drink. Meanwhile, the onlookers drank their *biche* with great relish and paid little attention to the proceedings. We left for our camp after the session was finished and returned the next morning to find all the Indians inebriated. Only men had been given the *biche* during the ceremony, but the women obviously had partaken later in the night. It was noticeable that the effects of the *biche* had been to make them insensible, rather than to make them sick, because the house was still clean. We cannot attest to the success of the healing, as the month-long "cure" was not completed when we left. Generally, the people seem to have a considerable faith in the powers of their *jaibaná*.

The Indians make two types of alcoholic liquor, *biche* and *chicha*. *Chicha*—a mixture of chewed maize and water that is boiled and allowed to ferment—is made only on rare occasions by the Noanamá. For more general drinking they make *biche*. A caldron containing sugar cane and water is allowed to ferment for a while and then is put on the fire and covered with a lid that has a hole in it. An earthenware distillation column, with a side arm to lead off the distillate, is placed on top of the caldron, and a condensing bowl of cold water rests on top of that. The water is changed regularly, and inside the distillation column there is a grooved wooden plate (placed underneath the condensing bowl) that collects the drippings. The system is arranged to lead the liquid into the side arm and finally down to the receiving vessel. The apparatus is glued together with a gum made from boiled bananas, and it works with surprising efficiency.

OUR last night on the Taparal, we had a party in one of the huts. The Indians brought *biche* and entertained us with music and dancing. Although the Noanamá have many different varieties of flutes and recorders, there was only one flute available that evening. It was accompanied by a drum, and other effects were produced by tin potlids and the like. The drum, slung over the player's right arm, was beaten on the skin with a hardwood stick covered with a small piece of fiber, and struck on the sides with an uncovered stick. The Indians danced *rumbas* and other Latin dances, which the men had obviously learned in the Buenaventura nightclubs and had taught to their wives. (The women never go into the town.) Rómulo, who led the dancing, asked to borrow a pair of trousers for these dances. Buenaventura dances apparently require Buenaventura clothes for authenticity. The Indians must wear trousers when they go into town, and one or two pairs of communal trousers are kept for this purpose in the hut nearest the mouth of the river. Rómulo later took off the trousers, started beating the drum with his hands, and led the Indians in tribal dances. He chanted monotonously, and the dancers followed him in chorus. The dance steps were all simple, and each dance varied only slightly from the preceding one. Both men and women took part, although they danced as couples in only one variation. Generally the men and women formed separate circles or chains and danced apart from one another.

Despite assertions by the Colombian anthropologist Gerardo Reichel-Dolmatoff to the contrary, it appeared to us that the Noanamá of the Taparal are undergoing a slow process of acculturation and integration into Colombian society. A few years ago a school was built at Cabeceras, an Indian community near the mouth of the San Juan. It was the first of its kind for the Noanamá, and its effects may be far-reaching. They are beginning to send their children to the school, although they clamor for another one at the mouth of their river. Travel to the present school takes four hours





**OSCAR,** *above,* a *jaibaná* of the Rio Taparal, sits behind balsa boat that was symbolic in his shamanistic training.

**CHILDREN** of Noanamá household, *left,* pose for photograph. Chocó Indian society is centered around its family units.

downstream and six hours upstream. Visits to Buenaventura have not left the men oblivious to the benefits of education, and most of them realize that their destiny lies in the hands of the government in Bogotá. (In fact, they requested us to see the President and ask him to build them a school.)

Education for a naturally intelligent and inquiring group like the Noanamá would not be difficult. Our friend Constanzo, for instance, was most indignant at not being able to get the bulb out of the flashlight we gave him, and on another occasion he asked me how the pattern on our *petit beurre* biscuits had been placed there. He appeared to understand when we told him the method.

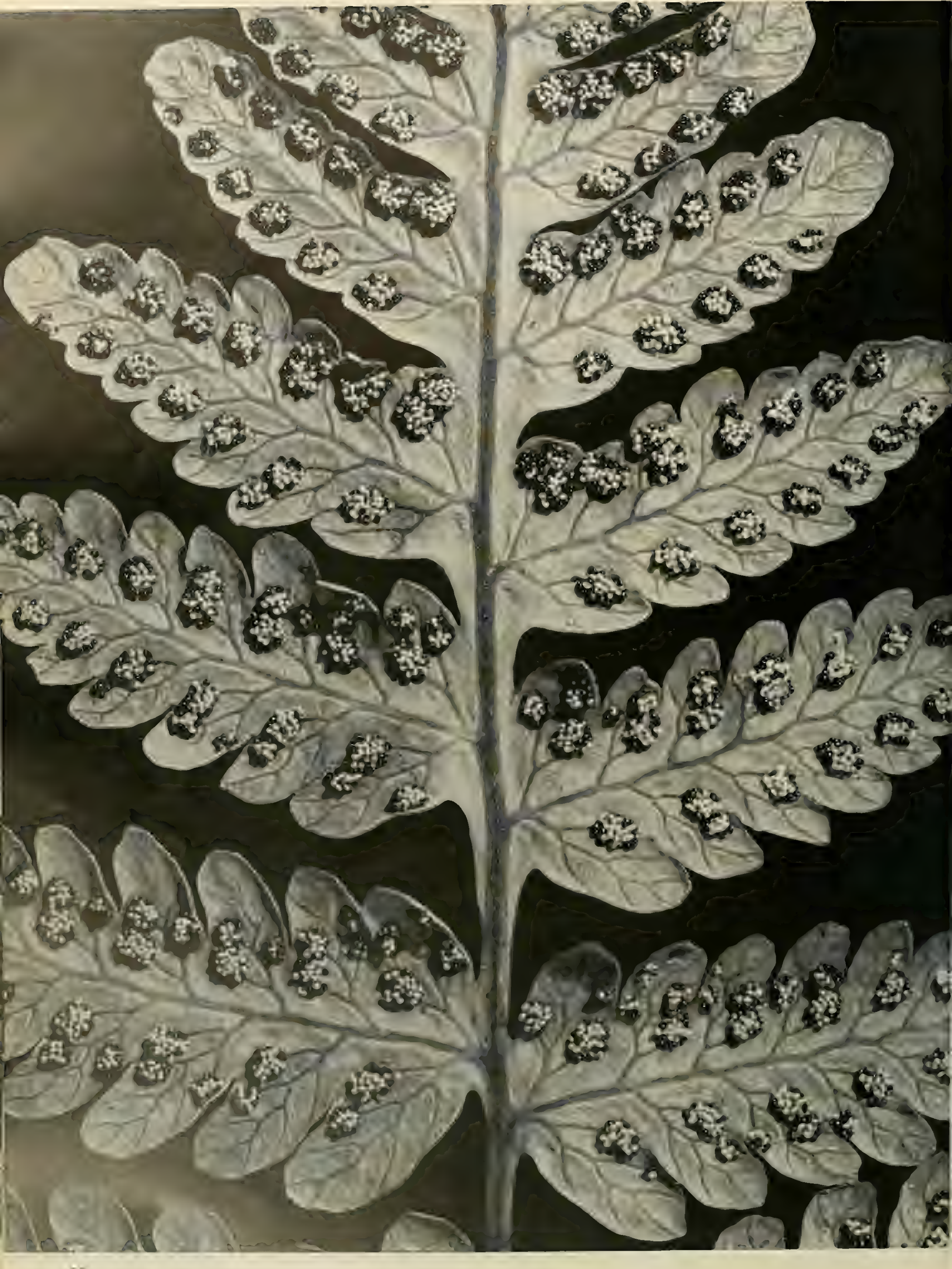
But what would be the effect of integration? The Noanamá are a happy group, and they work as hard as the climatic conditions allow. They are patient and ingenious craftsmen, and their relations with the Negroes are generally good. (The Negro and Indian populations in this area are practically equal in numbers.)

ONE reason for the happy atmosphere on the Taparal appears to be the lack of currency and trade among members within the community. Although they are accustomed to handling pesos in their dealings with the Negroes, the Indians never seem to pay each other for help in their forestry work or for food. They sleep in each other's houses and help themselves to each other's food on casual calls. Such is the friendship and intimacy within the community.

How long will this state of affairs last if and when the Indians get the education they want? It occurs to me that this area could be the site of a broad sociological experiment. Dr. Reichel-Dolmatoff has written that there are groups of these Indians withdrawing farther into the forest as more of the land comes under official control. These groups have apparently not heard of the education desired by more acculturated groups, and since the forests are practically impenetrable in some areas, these Indians are unlikely to be disturbed for some time to come. Many Latin American governments are concerned about the sociological problems of integrating indigenous populations. Here in the Colombian rain forests, at least, it is apparent that a partial and gradual process of integration will be possible.

BALSA wood toy, carved from memory by an old man, depicts horse and rider.

CANOE DRUM, strung from the roof, is played in ceremonial Noanamá rituals.



52

# BIOLOGY OF REPRODUCTION IN FERNS

By Kenneth A. Wilson

SMALL, brown bodies may often be seen on the undersurface of fern leaves, bodies that vary greatly in shape in different ferns. These structures, sometimes mistaken for insects or plant disease, are called sori and are clusters of minute reproductive bodies associated with the propagation of ferns. The study of the biological nature of these structures leads to an understanding of the method by which fern plants reproduce.

Ferns do not produce flowers, and seeds are never formed. Instead, small, single-celled bodies called spores function as reproductive bodies during the life cycle of the fern plant. The significance of the fern spore and the complexity of the fern life cycle was not understood until after the publication of Wilhelm Hofmeister's book *Vergleichende Untersuchungen,* in 1851. His discovery of what is termed alternation of generations was a significant milestone in our knowledge of the biological nature of the ferns and other plant groups.

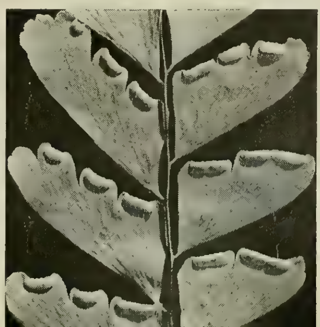
There are two strikingly different plant bodies produced during the fern's life cycle. The conspicuous and familiar green, leafy plant, known as the sporophyte generation, represents one of these. The other plant, the gametophyte generation, is delicate, small, inconspicuous, and very easily overlooked. A search in moist, shaded spots in woodland areas, however, may often reveal its presence. The sporophyte generation gives rise to the gametophyte generation, which in turn produces a new sporophyte generation.

The gametophyte develops from the spore produced by the sporophyte following the process of meiosis, during which the number of chromosomes in the nucleus is reduced by one half. The cells of the gametophyte, therefore, have nuclei with only half the number of chromosomes found in the parent sporophyte. The structure and form of the gametophyte vary in different ferns, but they are all small and their function is usually the same. It is this generation that produces and bears the structures associated with sexual reproduction. The eggs are formed in multicellular, flask-shaped, microscopic structures known as the archegonia, while the sperms develop in ovoid structures, the antheridia. The sperm, attracted by a chemical substance, swims toward the archegonium in a film of water. The fusion of the sperm with the egg, followed by the fusion of their nuclei, initiates the new sporophyte generation and at the same time restores the original chromosome number in the sporophyte nuclei by combining a set from each of the gametes, or sex cells. The cell resulting from the union of the egg and the sperm, known as the zygote, develops into the sporophyte. Cellular divisions of the zygote soon give rise to the embryo, which in turn grows into the familiar fern plant with roots, stems, and leaves.

It is known that a few ferns propagate themselves by vegetative means. The Bladder Fern (*Cystopteris bulbifera*) of the eastern United States produces green bulblets on the back of the leaf. When these fall to the ground they send roots into the soil, and soon a new fern plant is established. The Walking Fern (*Camptosorus rhizophyllus*) is so named because of the remarkable ability of its leaves to root at the tip whenever they touch the ground and produce a new plant, thereby appearing to "walk" forward. Several examples are known of ferns that, although they produce a gametophyte, bypass the process of fertilization and give rise to a new leafy plant by a proliferation of gametophytic tissue. The stimulus that triggers the formation of the sporophyte without involving the fusion of gametes is still a mystery.

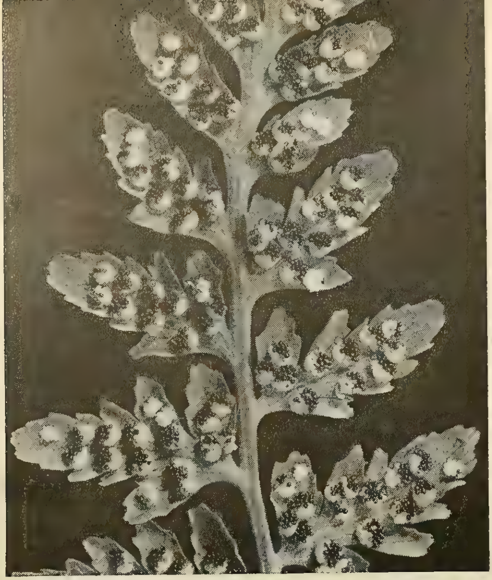
THERE are some 10,000 known species of ferns in the world, ranging from large, treelike forms more than sixty feet in height to minute, delicate, filmy ones less than one inch tall. Their stems may be horizontal and underground, erect and aboveground, climbing, or very short and crowded with leaves. The leaves themselves display a remarkable variation in their architecture. Most species have variously dissected, often lacy, blades, although leaves with the blades in one piece are also known. In spite of the variability in the structure and form of the fern sporophyte, all species, with but few exceptions, reproduce in the same manner.

The minute, dustlike spores are produced in spore cases known as sporangia. A magnifying lens will reveal that hundreds of these may be produced on the underside of a single leaf. These spore-producing structures are not scattered haphazardly on the leaf surface, but are neatly arranged in groups that form an intricate pattern on the lower leaf surface. These groups of sporangia are the sori. An exception to the patterned arrangement of sporangia in clusters may be seen by those



**OAK FERN,** *Gymnocarpium dryopteris,* has sporangia unprotected by indusia.

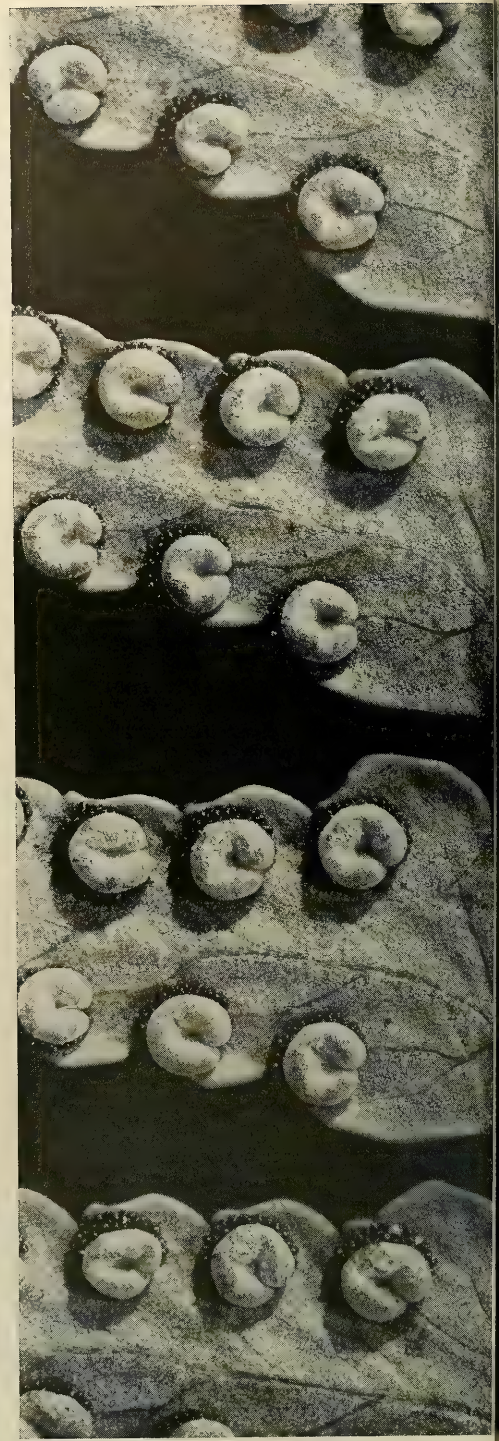
**MAIDENHAIR FERN,** *Adiantum pedatum,* sori are covered by folded leaf blade.

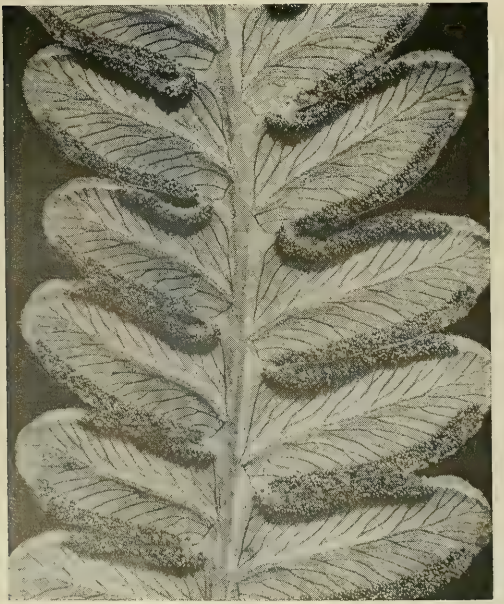


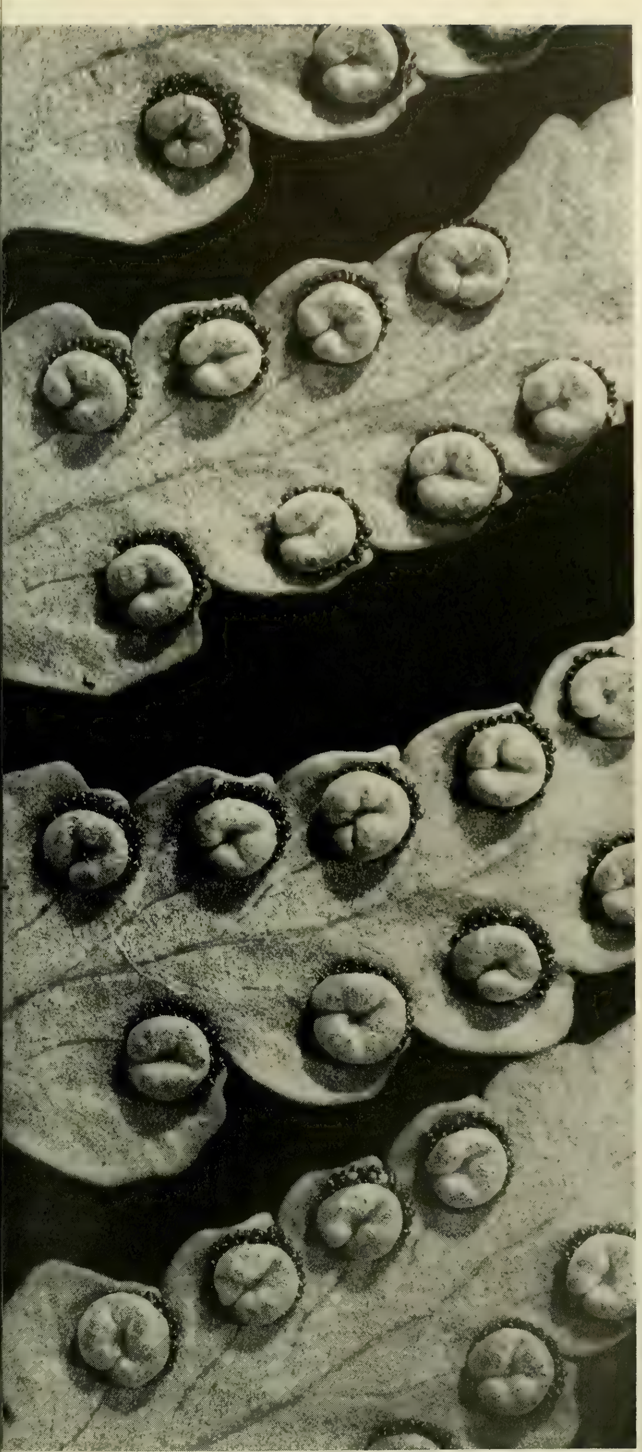
**Cup-shaped indusia** of hybrid *Cystopteris tennesseensis,* a Bulblet Fern, cover the undersides of the fertile pinnae.

**Groups** of sporangia of Evergreen (or Marginal) Wood Fern, *Dryopteris marginalis,* are covered by indusia, *right.*

**Bracken,** with varieties spread across the United States, bears precise rows of sori along the margins of the leaves.



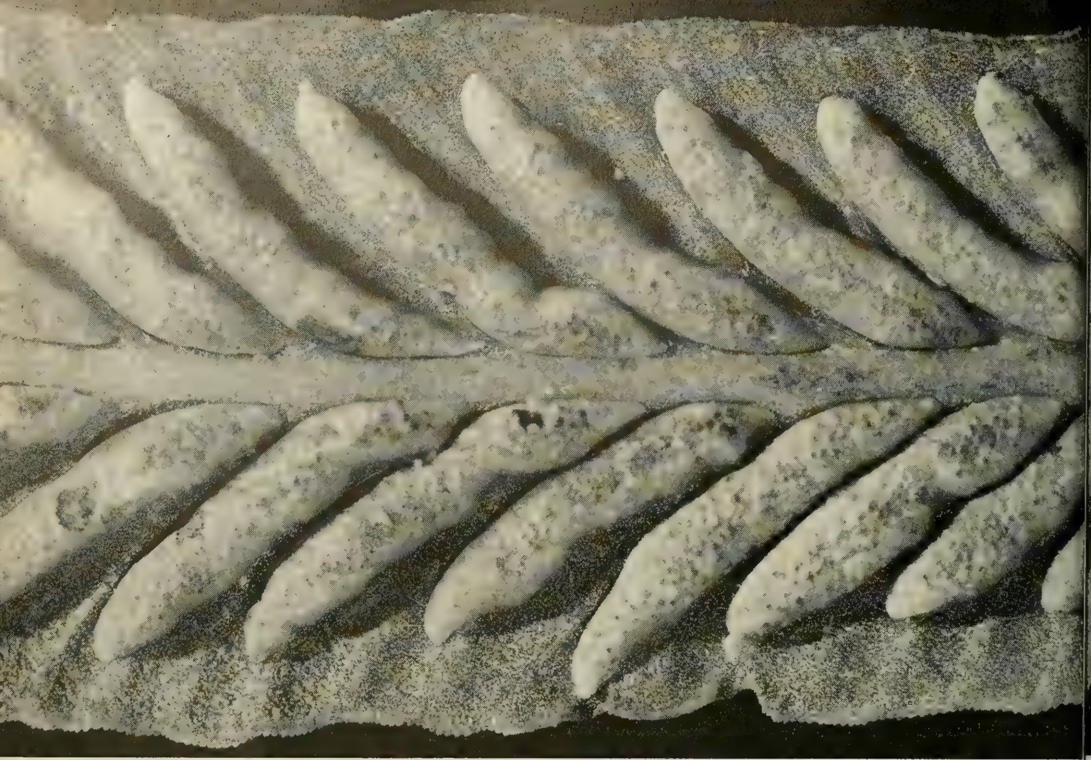




who have the opportunity to study ferns in tropical areas. Among the great diversity of tropical ferns, some produce leaves that bear sporangia over the entire undersurface, so that each leaf carries a coating consisting of a mass of spore cases.

The majority of ferns, however, both temperate and tropical, do bear their sporangia in the characteristic clusters. In fact it is the pattern and structure of these sori that aid in the identification of different kinds of ferns. In ferns of the genus *Polypodium*, which includes the common Polypody (*Polypodium virginianum*) of eastern America, the sori are round or elliptical and are seated at the end of a free veinlet. The sporangia in the sorus are not protected by any sort of a covering. An elaborate soral covering, known as the indusium, however, can be found in many ferns. This thin, membranous tissue may be seen blanketing the young sporangia in each sorus. Notice, for instance, the sori in the Evergreen Wood Fern (*Dryopteris marginalis*), which are located near the margins of the leaf blades (*at left*). Each young cluster of sporangia is completely covered by a kidney-shaped indusium. In the Christmas Fern (*Polystichum acrostichoides*), the indusium is shaped like a miniature umbrella or minute mushroom, each covering one of the closely packed sori. Other ferns bear their sporangia in long, linear sori following one of the veins. The Narrow-leaved Spleenwort (*Athyrium pycnocarpon*), on page 56, for instance, has linear sori that curve slightly, and each is covered by a long, membranous indusium that is attached at one side of the sorus, almost forming a pouch around the sporangia.

ONE of the leading fern specialists of recent times was F. O. Bower, who devoted much time to the study of fern sori. He postulated that, from an evolutionary point of view, the superficial position of the sorus on the lower surface of the leaf has resulted from a gradual transfer, or "sliding," of the sori from a primitive marginal position. This change, of course, has been a phylogenetic one, and is not easily demonstrated. Nevertheless, marginal sori are to be found in many present-day ferns. The sporangia of Bracken (*Pteridium aquilinum*), a worldwide species with many varieties, are arranged in continuous rows

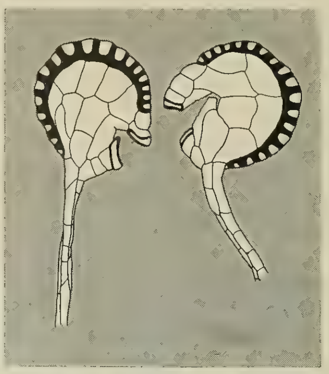


**Sori of the Narrow-leaved Spleenwort, magnified × 135, lie along leaf veins.**

along the margins of the leaf (*page 54*). In this fern, as well as in the Maidenhair Fern (*Adiantum*), the sori are covered by the reflexed margin of the leaf blade (*page 53*). This type of soral covering is frequently referred to as a false indusium, as it is the blade itself that folds back or rolls over to cover the sorus, while an indusium in the proper sense is a special tissue that surrounds or covers the sporangia. In addition to its inrolled leaf margin, the Bracken has an inner membranous, inconspicuous, flaplike indusium that may be seen in young sori with the aid of a lens.

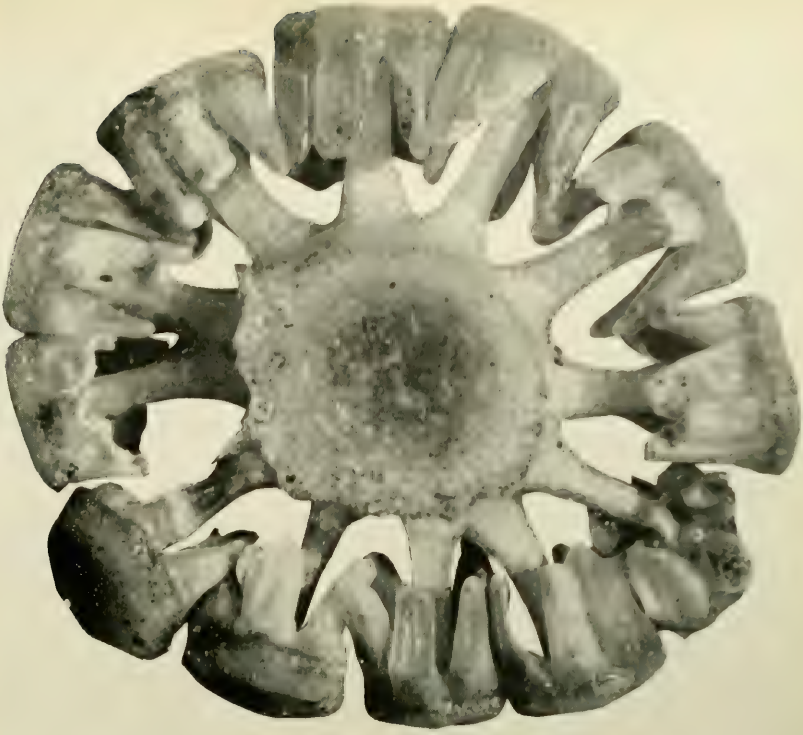
THE structural diversity of the indusium and the sorus is remarkable and readily observable. The indusium conceals the small sporangia until the spores are nearly mature. As the sporangia enlarge, the indusium is pushed aside and often withers, and spores are released from their cases.

The sporangia are very small, stalked, structurally elaborate capsules. When examined under a microscope, the stalk is seen to be composed of one to three rows of cells. The capsule, which is borne at the tip of the stalk, resembles a medieval helmet. A ring of thick-walled cells encircles the capsule from the stalk to the top (*drawing, below*). The function of this bowlike series of cells, often referred to as the annulus, is to rip open the capsule and propel the spores into the air. Horizontally elongated, slightly thickened cells in the capsule have a mouthlike appearance; in fact they are known as lip cells. Between the lip cells the mature capsule initiates its dehiscence. The drying and shrinking of the thick cells of the annulus pull the lip cells apart, and the capsule tears in a violent manner, exposing the spores. The annulus also acts in the manner of a catapult. The "bow" bends backward and suddenly jerks forward, hurling the mature spores into the air where winds and air currents may carry them a considerable distance from the parent plant. This fascinating process may be watched under a microscope or with a good magnifying lens if mature sporangia are used.



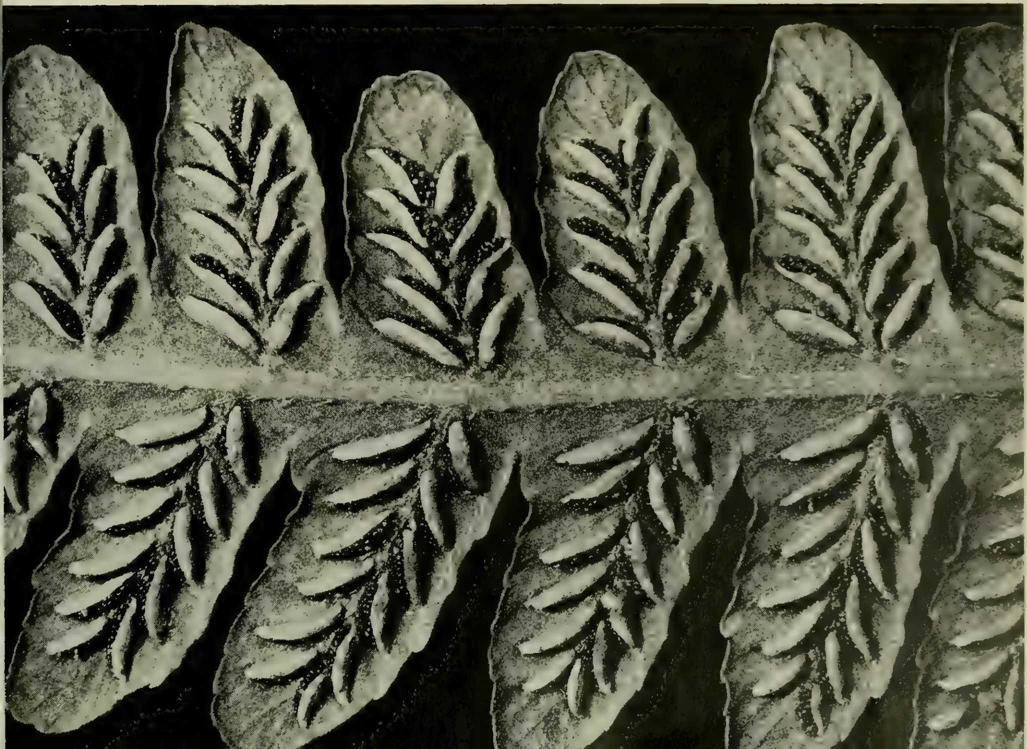
**As outer cells shrink, lip cells are forced open and spores are expelled.**

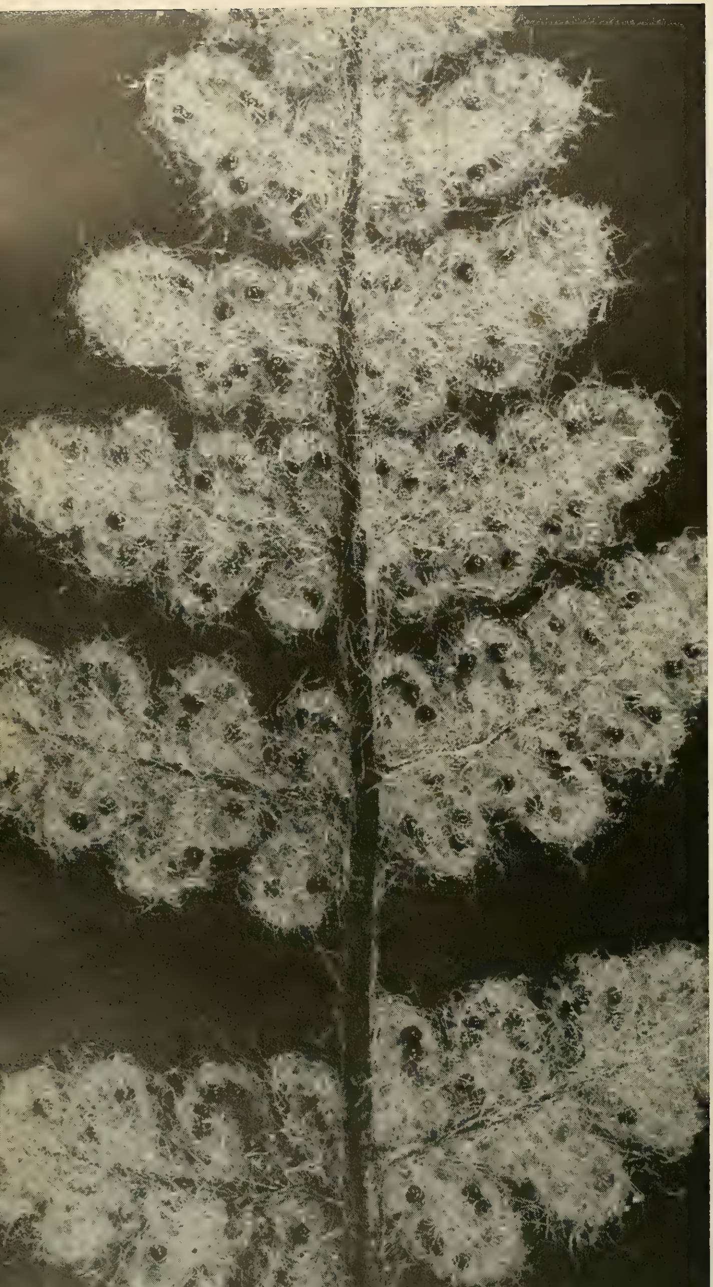
In the majority of present-day ferns, the basic structure of the sporangium is very similar. Subtle structural differences, however, do exist in such features as the orientation and number of cells in the annulus, the number of lip cells, and the number of rows of cells in the sporangial stalk. Each of these sporangia originate from a single cell of the leaf epidermis. The tiny cell enlarges gradually, and during its development becomes seg-



**Fertile cone** of a Horsetail, a fern ally, is in magnified cross section, *above.*

**Sporangia** are seen pushing out from beneath indusia of Silvery Glade Fern.





**Dense hairs** on underleaf of Slender Lip Fern partly conceal sori on tips.

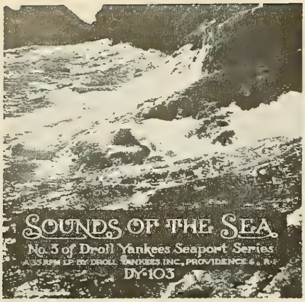
mented into five external segments that subdivide to produce the stalk and the capsule. A cell inside the young capsule gives rise to the spores and associated cells.

Some ferns have larger and sometimes more massive sporangia. In the Rattlesnake Fern (*Botrychium virginianum*) the sporangia are large enough to be seen with the naked eye. A special segment of the leaf bears the sporangia, while the other portion is a green, finely cut blade. The sporangia themselves are globular and are borne in two rows on the branches of the fertile segment. There is no indusium covering the spore cases, nor do the sporangia have an annulus. When mature, the sporangia open by a long, terminal slit. These sporangia also differ from those of most other ferns in that they are derived from a group of several cells, rather than from a single epidermal cell.

Rattlesnake Fern sporangia each produce well over 1,000 spores. Most other species are less prolific, ranging from 8 to 64 spores in each sporangium, with 32 the most common number. Estimates of the number of spores produced on a single leaf have ranged from 450,000 to over 52,000,000. Of course, only a very few of these spores germinate and develop into mature gametophytes. Factors such as moisture, light, and temperature control both spore germination and gametophyte development and, later, that of the sporophyte embryo, once fertilization has occurred.

The diversity of ferns is a dramatic result of their long evolutionary history. Fern students are still actively engaged in investigating the nature of this diversity and in attempting to understand the evolutionary processes that have given rise to such an array of plants. Not only do we see great variability in the size and structure of the sporophyte itself, but variation is also apparent in such microscopic structures as the sporangia and the gametophyte. These are currently being studied, and our understanding of fern biology is gradually broadening.

**Large sporangia** of Rattlesnake Fern are carried on a special leaf segment.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Arthur M. Greenhall, author of "Trinidad and Bat Research," is now Chief of the Mammal Section, Bird and Mammal Laboratories, Fish and Wildlife Service, Washington, D.C. However, at the time he wrote this article, he was Curator of the Royal Victoria Institute Museum in Port of Spain, Trinidad, W.I., and Zoologist for the Government of Trinidad and Tobago Ministry of Agriculture. He is a Research Associate at The American Museum.

Dr. Eugenie Clark, who wrote "Mating of Groupers," is Director of the Cape Haze Marine Laboratory in Sarasota, Florida, and a Research Associate at The American Museum. She has spent many years making studies of Red Sea fishes, and is presently pursuing research activities on the reproductive behavior of hermaphroditic fishes and the behavior and morphology of sharks.

The article on spider webs was written by Dr. Thomas Eisner, who is an Associate Professor of Biology at Cornell University, and is currently on sabbatical leave in the Netherlands. He was co-author of "Mystery of a Millipede" in the March, 1965, Natural History.

Canyonlands, the nation's newest national park, is the focal point of Stewart L. Udall's article, "The Ecology of Man and the Land Ethic." As the 37th Secretary of the Interior, Mr. Udall supervises the country's national parks, public lands, irrigation and reclamation activities, and has conservation responsibilities for national programs dealing with fisheries and wildlife. Through his many writings and speeches, Secretary Udall has undertaken the task of updating past conservation philosophy and programs for Americans of the sixties. A graduate of Arizona University, he is a lawyer by profession. His public service has been recognized by recent honorary degrees from Syracuse University, Dickinson College, and Colby College.

J. W. L. Robinson, author of "Chocós of the Taparal," was the leader of the Cambridge Calima Valley Expedition, 1962, which carried out archeological, botanical, and ethnological research in certain areas of western Colombia, and was a member of the Cauca Valley Expedition, 1964, which continued archeological research in the same area. He is presently working for a doctorate in biochemistry at the Université de Lausanne, Switzerland.

"Biology of Reproduction in Ferns" was written by Dr. Kenneth A. Wilson, Associate Professor of Biology at San Fernando Valley State College in Northridge, California. His current research centers on the morphology, taxonomy, and evolution of lower vascular plants.

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SCIENCE IN ACTION

# The sounds of singing

### By G. Stuart Keith

For two years, 1961 to 1963, my wife and I traveled widely in East Africa (Kenya, Uganda, Tanganyika), collecting birds and frogs for the Departments of Ornithology and Herpetology at The American Museum of Natural History. We did most of our collecting in rain forests, since they are the least known and most exciting parts of the country. I had become interested in recording bird songs before we left for Africa, so we had a tape recorder with us. What could have been more natural than to combine my collecting work with tape recording songs of birds in the rain forests?

There was another good reason for attempting this job—it had never been done before. Myles North, of Kenya, who has produced two excellent records of African birds, admitted that he knew only the songs of species that live in the dry savanna and thornbush country. Neither he nor anyone else was familiar with more than a handful of the forest bird calls, and no one had recorded them.

An African rain forest is composed of tall evergreen (but not coniferous) trees, some of which reach 150 or even 200 feet. There is generally a thick canopy above, but not so thick that all light is shut out from the forest floor, where there is often a thick undergrowth that varies in density with the amount of light admitted by the canopy. Many trees rise 50 or 75 feet before branching, but in clearings or more open areas, they branch much lower down. At the edge of the forest there is a dense ring of second growth—which one has to hack one's way through to enter the forest proper—characterized especially by tangled vines and creepers. Rain forests, as their name implies, are generally wet, and during the rainy season they can be dark and depressing places. They occur in areas of high rainfall such as mountain slopes, humid valleys, and along the banks of the larger rivers.

Bird song is one of the most fascinating, yet tantalizing, aspects of a rain forest; fascinating because of its enormous variety and because of what, to our ears, are strange and unusual sounds incorporated in it; tantalizing because it is so hard to see the birds themselves in the dense undergrowth and high canopy. Birds sing and call all around, but it is difficult to get a good look at them, and the shyer ones are just not visible at all.

English settlers in Kenya often complained that the birds in Africa do not sing. What they meant was that they heard no songs comparable to those of the familiar English blackbird and robin. It is true that there are not many birds in a rain forest with the beautiful, throaty warble of a blackbird, but to me their voices do not lose in interest on this account. I enjoy the monotonous "bok-bok-bok-bok" of the tinkerbirds—small barbets so named because their song was likened to the noise made by hammering on a piece of metal. I am amused by the sometimes squeaky, sometimes grating, but often tuneful songs whistled by the multitude of bulbuls in the forest. These are thrush-sized birds that look very much alike, but often sound totally different from one another. The gravelly bark of the turacos—gorgeous green birds with a flash of red in the wings—is one of the most typical rain forest sounds. I like the high, tinny songs of the sunbirds, the grating calls of the drongos, the mellow "hoodle-ee" of the orioles, the raucous cries of the hornbills, and, at night, the hooting duet of the African wood owl. Nor are the rain forests without fine singers; the Maria Callas of the Mount Kenya forests is Ruppell's Robin-Chat whose varied repertoire, powerful voice, liquid and beautiful notes, and powers of imitation make him one of the top singers of the world.

The stage is set. You are inside a forest; you can hear birds singing; how do you go about recording them?

## The Equipment

I cannot here engage in a long discussion of all the types of equipment used in field recording, but I will give a brief description of what we used. We had one (and later bought a second) Swiss tape recorder. It weighs twenty pounds, which becomes quite a weight after a mile or two, but it is sturdily built and almost trouble-proof. We had several microphones (more than one is essential, since few can withstand the rough and tumble of travel in Africa for long), and two parabolic reflectors, one 17-inch and the other 36-inch. A parabolic reflector is a shallow dish that picks up sound waves and gathers them into a focal point within the dish. The microphone is placed at that focal point and the sound it receives is thus greatly magnified. A parabolic reflector is to tape recording what the telephoto lens is to photography; one can work at a distance.

So now you have a 20-pound tape recorder over your shoulder; you have the parabolic reflector in one hand. (I almost always use the smaller 17-inch reflector inside forests; the bigger one is too heavy

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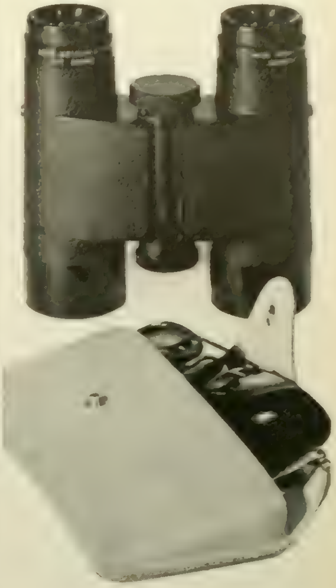

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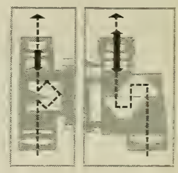

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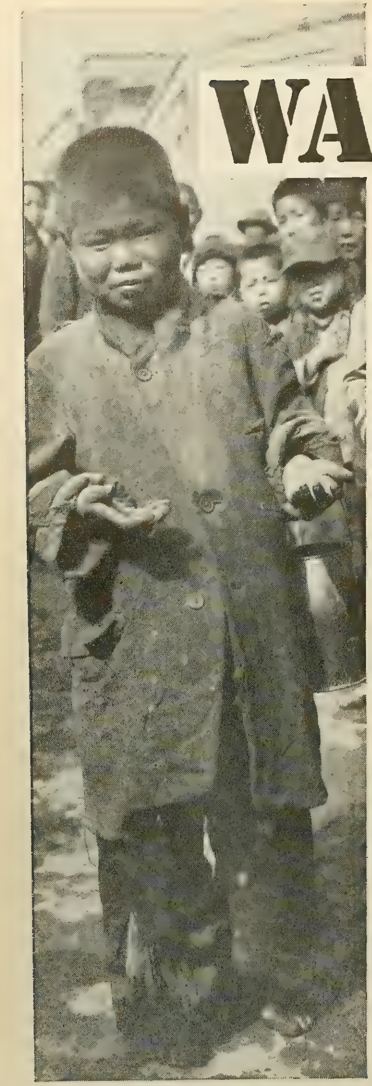

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and unwieldy, and is impossible to carry through undergrowth.) The microphone is attached inside the reflector and connected to the recorder with a 6-foot lead. You have a spare tape in one pocket. You have binoculars around your neck. You very likely are also carrying a collecting gun, and if it is wet you have a raincoat over yourself and the recorder, and perhaps even a small campstool to rest the recorder on.

## Patience and Fortitude

With such a lot of equipment, the one thing you do not do is to go rushing off after the first bird you hear singing. You must select your quarry with great care. First, wait to see if it is singing regularly. Was it a chance call, a small snatch of song, or does it seem to be singing determinedly? Is it the sort of bird (and you won't be able to answer this question until you have had some experience) that tends to sing once or twice and then wait for 15 minutes, or does it go on and on once it starts? How much closer will you have to get to it before you will be within range for a good volume recording? Is it a shy or a bold bird? Can you sneak up on it without making too much noise, or is there impenetrable undergrowth in your way? Often there is a choice of birds to record. Is the bird you hear a common one, the sort you should be able to record anywhere, and is there not something less common also calling that it might be better to try for? All these decisions and value judgments will, of course, become easier the more familiar you become with the forest birds, but I often found myself torn among several different species.

Let us suppose you have selected a Joyful Greenbul, a handsome yellow and green bulbul with a vivacious, bubbling song, that is singing loudly nearby. You can almost record it from where you stand. You know it is likely to continue singing for a bit, being a talkative bird. It is more interesting than anything else you can hear. It is not too shy a bird and you succeed in getting close enough to make a good recording without disturbing it. Do you switch on? Not yet.

Now other problems develop, in the form of background sounds. Your Joyful Greenbul is one member of a large party that is moving noisily through the middle and lower levels of the forest searching for insects among the leaves and along the branches. Paradise Flycatchers are whistling, drongos are screeching, sunbirds are chattering, a pair of Luhder's Bush Shrikes are duetting, and the total volume is terrific. If you switch on now, you will get your Joyful Greenbul, but you will get a great many other birds as well. If you are trying to get a "dawn chorus," or a general mood picture of forest bird song, your recording will no doubt be excellent. But if you are trying

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to build up a series of individual bird songs, as I was, you will find that the other bird calls on the tape are distracting and annoying. What can you do about this? Nothing, for the moment. You must try to follow the bird party, if possible, and wait until the Joyful Greenbuls lag behind or become separated. Of course, by this time they may no longer be singing, and your tramp through the forest may be in vain, but that is a chance you must take. The primary requisite for recording rain forest birds is patience.

Let us suppose you have followed the party for twenty minutes and the Joyful Greenbuls have become bored with their companions and are on their own, singing a song of relief at having escaped the crowd. Do you switch on? Not yet.

A wind has sprung up, the tops of the trees are swaying, and the leaves are rustling. Your microphone is sensitive not only to bird song; it is sensitive to all sounds, and the noise of the wind in the leaves is faithfully recorded on the tape as a loud roar. It is astonishing how many decibels wind can produce. To begin with, I had many, many recordings wrecked by a loud background of wind. Now I have learned my lesson, and if there is any wind I simply don't switch the set on at all.

Finally the wind dies and all is still. The other birds have vanished. One of the Joyful Greenbuls looks at you, decides you have had a tough break, and sings his sweetest refrain for your benefit. Now you may switch on your set.

Until you start tape recording, you don't realize how many sounds you hear every day, all the time, without really "hearing" them. This is because our ears or, rather, our brain "tunes out" all sounds it considers irrelevant. When having a telephone conversation from what may be a noisy office, you only really "hear" the voice of the person on the other end of the line because that is what is relevant to you at the moment. Yet, while you are talking, all kinds of other sounds are being received by your ears—other people talking, doors opening and shutting, typewriters clacking, and so on, but your brain has tuned them out. The microphone plays the part of your ear, but it cannot also play the part of your brain; it cannot tune out irrelevant noises. In a rain forest, you only hear bird songs because that is all you are interested in. Until you have trained yourself to do so, you do not hear the other background noises that could mar your recording. An essential act before switching on is to point the microphone at the bird you want to record and then listen through the earphones for background noise. In Africa there is very little trouble from cars and almost none from planes, these being the two main bugbears in recording in this country, but it is astonishing how much extraneous

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noise remains. Africans are shouting to one another, someone is chopping wood, children are playing, chickens are clucking in a village at the edge of the forest. (The number of chickens in Africa must be astronomical, to judge from the number of times they appear as background to my forest bird songs.) Crickets and other insects often make recordings impossible. Streams and rivers are a menace, producing a roar similar to that made by wind. Recording anywhere near the sea is, of course, out of the question. Rain and the aftermath of dripping leaves is a problem. One beautiful cut of a Blue-shouldered Robin-Chat I made was ruined by a couple of loud "spats" as heavy raindrops hit a big leaf near the singer. On another occasion our African cook yelled to me that tea was ready just as a Nicator Shrike was recording his full range of calls into the mike. That was the last time I did any recording within earshot of camp, and I admit it was a stupid thing to have attempted in any case.

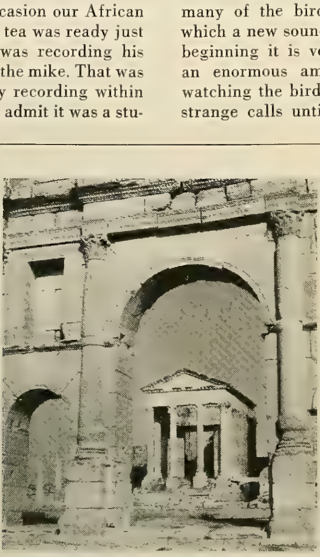
I have not yet come to one of the most trying problems of all in recording birds in the forest—that of identifying the singer. The Joyful Greenbul was easy. It is not a shy bird; it feeds at about eye level, and is readily distinguishable in the field by color. Other cases are much more difficult. Many bird parties pass through the canopy, which may be 100 to 150 feet above. The birds are hard to identify there, being far away and often against the light or in shadow. Add to this the task of seeing which bird is making the call you have just recorded, and things can get very difficult. As you get to know more and more of the birds, you can soon start to eliminate as possibilities many of the birds in the group from which a new sound is coming, but at the beginning it is very confusing. I spent an enormous amount of time simply watching the birds and following up all strange calls until I could identify the common ones. The first time I met the Honeyguide Greenbul, in Kakamega Forest in western Kenya, I heard the song in the canopy for nearly ten days before I finally caught sight of a singing bird. Like a great many other forest birds, the Honeyguide Greenbul spends most of its life high in the thick foliage of the canopy, seldom coming down to lower levels where it could be easily seen.

**Mr. Keith**, Associate, Department of Ornithology, **The American Museum**, has been in East Africa for most of the last three years, where he was collecting birds for scientific study.

Undergrowth birds create equally trying problems in identification. Here you often do not see the bird at all in the deep shadow and tangled shrubbery. The Scaly-breasted Illadopsis, one of the babblers, has a distinctive, clear, ringing whistle of three notes that go up the scale, each a semitone higher than the last. You hear this call all around you in most of the forests of Uganda and western Kenya, but to see the bird is almost impossible unless you catch it in a mist net. I recorded the song long before I saw the bird, and identified it only by playing back its song and thus enticing it from its retreat. This is an effective method of identifying mystery singers, and I am indebted to it for a number of identifications of songs whose owners I have not yet seen singing.

Not all birds play ball in this way, however; some take the playback of their song as a challenge, and simply sing louder from where they are hidden. Sometimes the bird will come in answer to a playback of its song, but will remain partly hidden in the bushes. In these cases I resort to a collecting gun, and, in fact, whenever identification is difficult one should collect the bird. A "probable" identification is scientifically useless.

Although I have dwelt long on some of the problems involved, do not think that this kind of recording is only a great deal of work for a small reward. I love rain forests and rain forest birds, and although on occasions I may be frustrated, I am never bored. There is always the challenge of identifying a new song, of sorting out the repertoires of birds with more complicated vocabularies, of recording a bird that only sings a few short bars and then waits for twenty minutes before calling again. There is the excitement of discovery. Not only have most of the birds never been recorded before; in some cases their songs have been completely unknown, or poorly described, or several quite different songs have been lumped together under one species. It is good to feel one is breaking new ground. To start recording and hear through the earphones a rare and exciting bird singing clearly is one of the most satisfying feelings I know.



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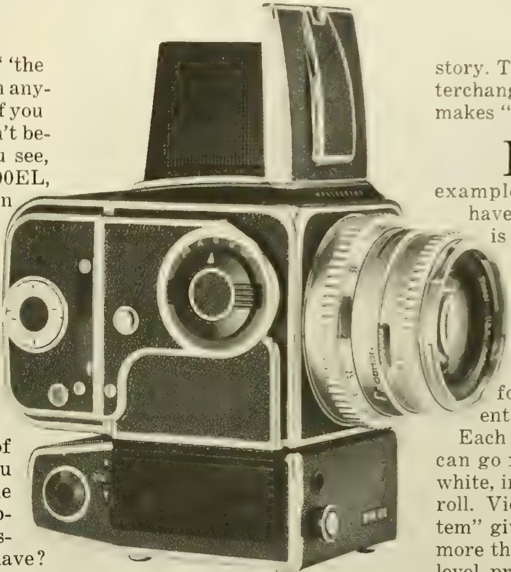

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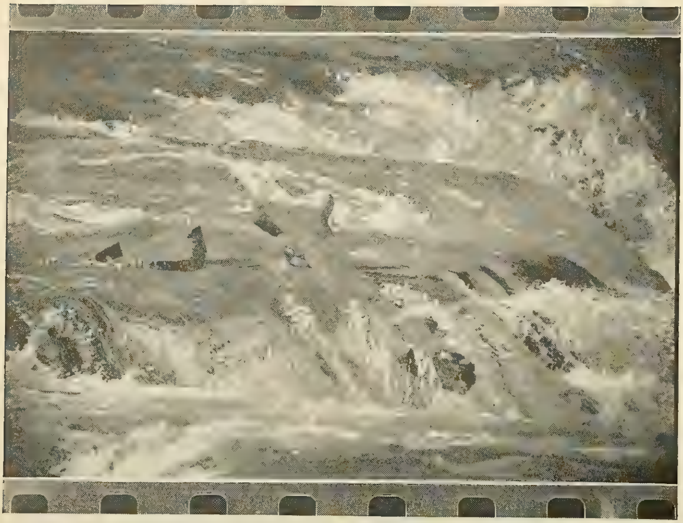

**BRINKMANSHIP AT NIAGARA FALLS**

We were astonished to find that an 8x10 enlargement of this Questar high-resolution closeup had the quality we would expect from a press camera only a few feet away. As this log teetered here on the brink for a few moments, perhaps you can see how tiny droplets of water were stopped cold at f/18, on Tri-X film at 1/500 second. Please notice the tremendous depth of field! That's what small aperture and great distance make possible. The grain was negligible, too, so we doff our hats to Kodak for this splendid negative material. Camera was a Questar-modified Nikon F, available only through us.

We left the sprocket holes on this section of 35-mm. film for you to see. It is always nice to publish a closeup picture that could not possibly have been faked, save perhaps from a balloon. We doubt if any other telescope could take so sharp a picture, for many reasons.

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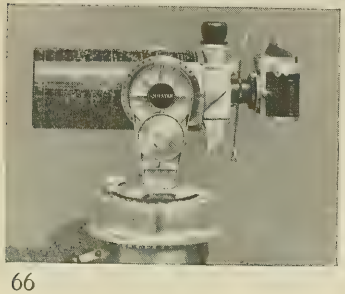

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# nature and photography

## Varying exposure for desired effect

### by Jack Couffer

MOTION-PICTURE producers take it for granted that professional cameramen will unerringly produce a negative that is correctly exposed from all technical aspects. It is simply *assumed* that every scene will have the proper exposure when related to a mathematical scale or to a density-reading machine. But while, on one hand, there is a definite numerical correctness to an exposure reading, there is, on the other hand, an exposure abstraction that has to do with the particular photographic effect that is desired in the film.

In motion pictures or in stills, effect desired is not a cut and dried figure indicated by the light meter. Even with exposure—the most elementary basic of photography—subtleties of individuality and creativity are involved. Although proper exposure can be measured on a graph, effect desired brings in whole new elements of taste and interpretation.

One cannot speak of exposure without speaking of lighting, and vice versa. The mood of a scene is conveyed in the quality of its lighting, and the lighting is captured by the exposure. A conventional daylight shot is made with the bright, full sun behind the cameraman's shoulder. This is the front-lighted subject, the average scene, and certainly it is a useful lighting situation and one that we frequently employ. One must not, however, feel limited to this. For a specific effect we can point the camera in any conceivable direction relative to the light source. We can even (and sometimes with very good effect) shoot directly into the sun. Refractions, halos, distortions, flares, and other technical imperfections can become abstractions all working to enhance the scene.

As we reject rules on where to aim the camera, we can also deviate from conventional rules on exposure. It is frequently necessary to vary from the light meter's dictum to obtain mood. For example, with a scene in which the cameraman wishes to gain the feeling of an oppressingly hot, stark mood, he may wish to use flat light and to overexpose slightly from the normal as established by the light meter. The photographed scene now becomes lighter and brighter than the "correct" meter reading. But the exposure gives us the desired effect.

More often the wildlife cameraman departs from the value indicated by the light meter and leans toward underexposure. Twilight and evening moods, silhouettes, sunsets, and sunrises are frequently embellished by this technique. Underexposure is also a useful aid in establishing night effects when filming in daylight.

The home-movie maker who wishes to film a night sequence in color might try using a color film that is balanced for tungsten light. Shoot the film outdoors in sunlight without using the manufacturer's recommended color-balancing filter. Without the filter, underexpose 1½ to 2 stops from the correct exposure as indicated by the light meter. The best day-for-night scenes are usually filmed in ¾ backlight (that is, with the sun striking the subject at an angle of ¾, or approximately 100 to 135 degrees away from the camera), and the effect works best when the subject is in strong sunlight surrounded by deep shadows. No fill light should be used. It is the sharp contrast that makes the effect. The result is also good when the subject moves through broken patterns of deep shadow and strong sunlight (which now is passing for moonlight).

## Light Control

IN wildlife photography in the field, it is frequently difficult to control the light on a subject. However, I would never take it for granted that light control is impossible. Whenever possible, one should have at least one good reflector among one's camera equipment. A perfectly satisfactory reflector can be made from a sheet of ⅜ inch plywood with aluminum foil pasted smoothly on one side. The reflectors I use are standard-sized motion-picture reflectors four feet square. Smaller sizes can be useful and are more portable, but generally speaking I do not consider a reflector smaller than three feet square worth having. The size of the light beam produced by smaller reflectors is useless except in very close work.

When working with a reflector it is frequently necessary to have an assistant to direct the light. The moment the assistant hears the camera start he must refrain from moving the reflector (even at the cost of losing the subject in the light beam), or light will move on the subject in a disturbing, unnatural way.

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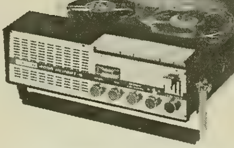

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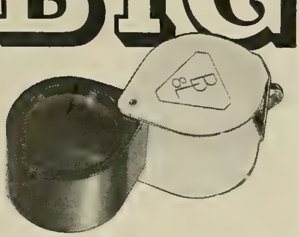

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JACK COUFFER, a research biologist who turned to wildlife photography, has been director and cameraman for many Walt Disney productions. He is the author of *Song of Wild Laughter*, published by Simon and Schuster, Inc.

The reflector in wildlife photography is useful for three main purposes: as a fill light to bring the light level of shadowed areas up closer to the level of surrounding sunlight; as a keylight to illuminate specific small areas in deep shadow; and as an eyelight. It is in this last capacity that I use the reflector most frequently. In close-up studies of animals, the eyes are frequently lost in shadow. Particularly in back-lighted scenes, the eyes may disappear in the shadow of the face, and an eyelight in such a situation can make all the difference between a good shot and an unusable one. A bright glint to the eye is what gives life to a portrait.

## Back Lighting

I recently completed a film about the coyotes that live in the undeveloped Hollywood Hills between the city of Los Angeles and the San Fernando Valley. The hills are covered with dusty brown chaparral and dry grass, and the coyotes' brownish fur blends in with this background. In a conventional front-lighted scene (with the sunlight coming from behind the cameraman's shoulder), the coyotes were nearly impossible to see, much less to photograph. It was only by using backlight that we were able to photograph coyotes in this natural habitat successfully. With the shadowed side of the animal toward the camera, the coyotes showed as dark forms against the lighter grass. The effect of the backlight also worked to the advantage of the mood in giving a nocturnal feeling to many of the sequences that were actually filmed in daylight.

Artificial light also has its place in photographing wildlife. Tabletop setups for insects and small animals, aquariums, and botanical, archeological, or geological studies can perhaps be filmed best with artificial light sources. Photofloods and the new quartz lights can, with ingenuity, be controlled almost as effectively as studio lights. The heat produced by bright lamps must be controlled with the frail specimens (such as insects) that are easily burned. It is frequently possible to cut down lamp heat by directing the light through a vessel of water.

It is always surprising to me to see the complete lack of concern some wild nocturnal species often have for bright lights set up at outside feeding stations. I have seen ring-tailed cats, foxes, skunks, deer, raccoons, and many other animals come into feeding stations at night and show little or no reaction to

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bright lights suddenly switched on from a photographic blind. If it is desired to set up such a photographic situation, and if wildlife does react unfavorably to lights, it is possible to condition them to the light by bringing the level up slowly, using a dimmer or rheostat.

## Weather and Photography

In motion-picture production much time can be lost in waiting for clouds to move across the sun. Visitors to a location frequently assume that it is impossible to shoot during the flat gray interval when the sun is behind a cloud. Actually, on days of intermittent overcast we sometimes spend as much time waiting for clouds to cover the sun as we do for the opposite effect. It all has to do with the mood we hope to establish and with the light condition that existed when a sequence was begun. A sequence of shots that will eventually be cut quickly together, one after another, to tell a story that has continuous action, must have a continuity of light. Of course, it would not do to have a sequence of continuous action intercut with shots made in sunlight one moment and rain the next. The effect would be jarring and show clearly that the continuity was manufactured in the cutting room by splicing together pieces of unrelated film.

In wildlife photography, particularly in color, unusual conditions of light are most desirable and contribute to the over-all effect. Fog, mist, overcast skies, early morning or late evening light all are conditions that should be sought after as embellishments to the wildlife photographer's work. The problem with unusual lighting conditions is that a given quality of light is frequently not of long duration and, as I have mentioned, a continuous action sequence should be completed in the kind of light under which it was begun.

On some occasions I have started work under an unusual kind of light and have not finished the sequence. At times, when there was a long wait until a similar condition again existed, I found it expedient not to try my patience; instead, I started all over again.

It is frequently said that wildlife photography is all waiting and patience. I have done a lot of waiting, but not, I confess, always with patience.

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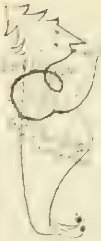
This list details the photographer, artist, or other source of illustrations, by page.

COVER—M. Woodbridge Williams, National Park Service
14-21—H. Drysdale, Trinidad Regional Virus Laboratory except 18—bottom left, AMNH after Arthur M. Greenhall
22—William M. Stephens
23-25—Cape Haze Marine Laboratory except 24—left, AMNH after Eugenie Clark
26-31—Thomas Eisner except 28—bottom, AMNH after Eisner
32-41—M. Woodbridge Williams, National Park Service except 34—bottom, AMNH after National Park Service
42-44—Official U. S. Navy Photograph
45—AMNH
46-51—A. R. Bridgeman except 49—bottom left, AMNH after J. W. L. Robinson
52-59—Charles Neidorf except 56—bottom, Kenneth A. Wilson



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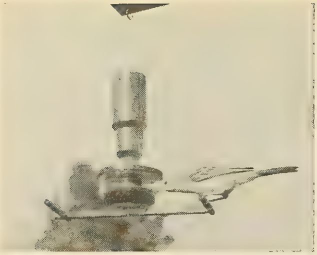

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SNAKE-HUNTERS' HOLIDAY. R. L. Ditmars and W. Bridges. D. Appleton-Century Co., N.Y., 1935.

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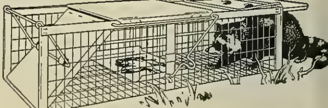

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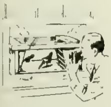

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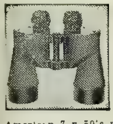

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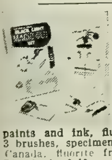

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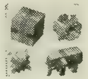

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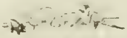

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# Natural History

August–September 1965 • 50¢

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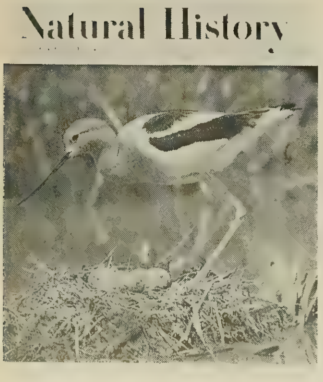

# Natural History

Incorporating Nature Magazine

*THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY*

Vol. LXXIV AUGUST-SEPTEMBER 1965 No. 7

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COVER: The nest of the American Avocet is a small, flat-topped mound, covered with rough grass and roots. As seen in the cover photograph by Willard Luce, it is usually built in low vegetation, in a marsh, or near water. The variation in the form and structure of bird nests has long been a subject for investigation by ornithologists. Dr. Nicholas E. Collias, in an article beginning on page 40, discusses the many ecological and behavioral forces that have shaped, through long evolution, the nest-building patterns of various species, making each one's habitat a thing of great simplicity or of an apparently fantastic elaborateness.

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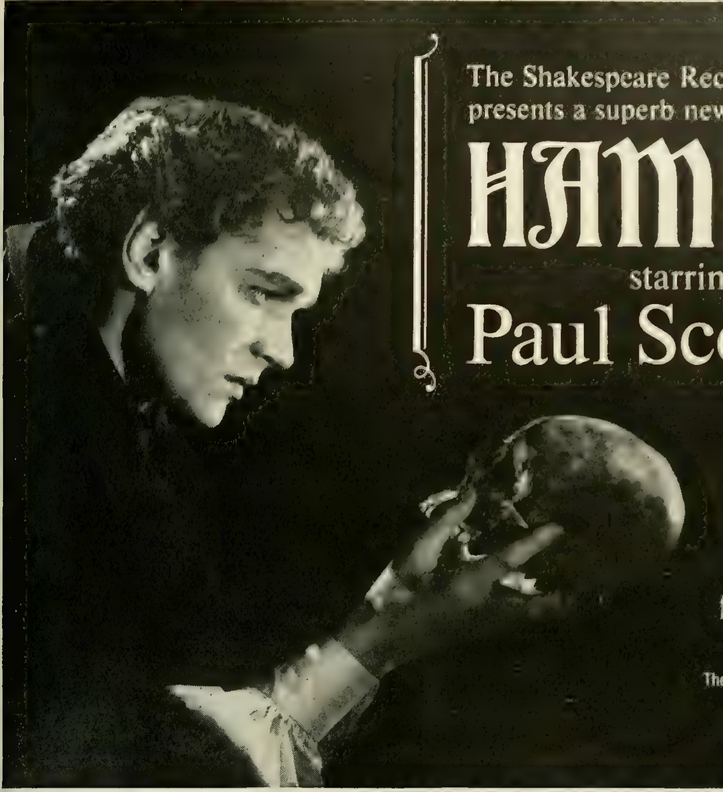

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Originally, this splendid program seemed an impossibility. Records had to be kept of thousands of little details. *The work each volunteer did, the food rations earned, the progress of each village on each project —these were only a few of the items that had to be recorded and analyzed quickly—and economically.*

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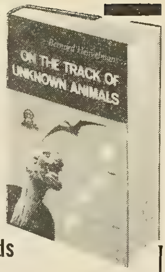

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*BOOKS IN REVIEW*

# Studies in entomology

*By Syd Radinovsky*

The Life of Insects, by V. B. Wigglesworth. *The World Publishing Co., $12.50; 360 pp., illus.* The Insects, by Url Lanham. *Columbia University Press, $6.95; 292 pp., illus.*

Insects have been here for a long time and are here to stay, whether we like it or not. Perhaps no other group of animals has affected man more than insects. The authors of these two books present novel approaches to an old subject that should appeal to the beginning entomologist, the student of entomology, and the non-entomologist interested in learning about an animal group that comprises perhaps three-quarters of the animal kingdom.

The content and manner of presentation is a welcome change from the stereotyped, conventional, dry entomology texts. The lucid and eminently readable expositions, coupled with the delights of the descriptive passages, warrant readings by a large cross section of Natural History readers.

Dr. Wigglesworth, in *The Life of Insects*, places little emphasis on phylogeny and classification and much on natural history, general biology, behavior, and physiology without getting involved with the recondite details of biochemistry and biophysics. Excellent accounts are given of the adaptation of insects to land, water, and air. A clear account is given of insect flight. In the chapter "Dietary of Insects," the author discusses evolution of insect mouthparts, feeding methods, and insect food.

Other exceptionally noteworthy chapters are "Defense and Offense," which discusses the diverse mechanisms that insects have evolved and that are no doubt partly responsible for the tremendous success of the group, and "The Wisdom of the Insect," perhaps the most exciting chapter of the book, which relates instinct, tropisms, orientations, sense organs, sun compass reactions, memory, learning, "releaser" stimuli, token stimuli, physiological clocks and diurnal rhythms, and insect behavior, and paves the way for the chapters on "The Organization of Insect Societies." In the chapter "Insect Populations, Speciation, and Migration," we get a glimpse of the insect as a member of the population, the factors affecting survival of the population, and the steps that lead to speciation. The concluding chapters, "Insects and Flowers" and "Insects and Man," again point out how significantly insects affect us. The all-important and controversial problems of pest control are discussed here.

In the appendix is a "Catalogue of Insects," a thirty-page résumé of the twenty-eight orders of insects, concise and compact. The chapter-by-chapter bibliography is evidence of the wide usage of the "old" and the "new" research. It is a complete and up-to-date source of information for the reader interested in following up in greater detail any of the diverse subjects treated in the text. A short glossary is followed by an index.

The diagrams and the photographs in both black and white and color are excellent. Many of the diagrams are borrowed from the best of the old classics, and the combination of the old with the new adds much to a book that is one of the best in twenty-five years.

In *The Insects*, Dr. Lanham stresses paleontology, phylogeny, classification, arthropod relationships, and morphology (relating structure with function), but he also discusses extensively, although in a non-technical manner, insect biology and behavior, insect distribution, and insect dispersal. The section entitled "Insects and Their Environment" deals with climate and season, population dynamics, insects and plants, insects and other animals, insects versus insects, aquatic insects and their origins, and the adaptive significance of coloration in insects.

"Parade of the Insects" is a novel treatment of the insect orders, with detailed accounts of their phylogenetic position, paleontology, general morphology and biology, natural history, and evolutionary significance. Economically important insects are cited and examples of chemical and biological control are given. In "On Stings and Society," there is an excellent account of social insects. Parasitic Hymenoptera are distinguished from social Hymenoptera according to structure and function, and the transition from solitary to social forms is discussed in detail. A comparison is made between the stereotyped instinctive behavior of insects and the flexible behavior shown by some mammals.

In a concluding chapter, Lanham points out the similarity in structure, diversity, and abundance of insects today with those at the beginning of the Cenozoic Era. "Probably the most notable changes are involved in geographic distribution due to a changing

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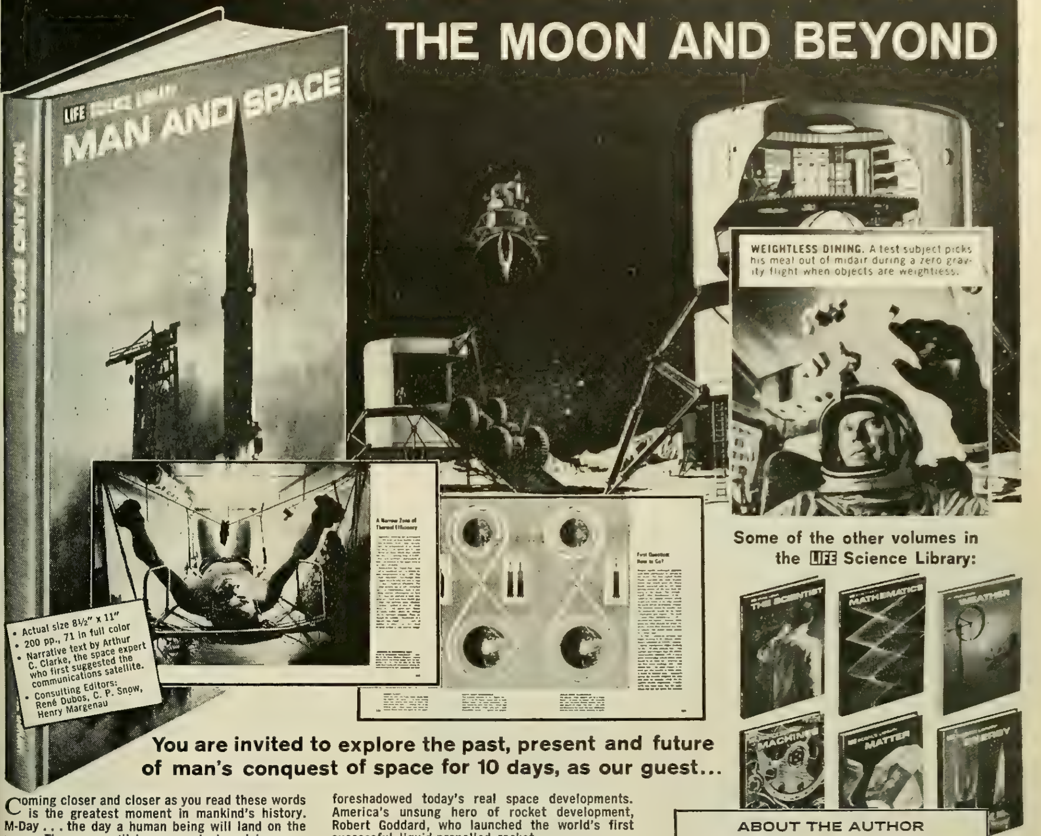

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### ABOUT THE AUTHOR

Twenty years ago, Arthur C. Clarke wrote a technical paper which first suggested the communications satellite. For this he was awarded a gold medal by the Franklin Institute. He has an international reputation as an authority on space and as a science-fiction writer, and has written some 30 books published around the world in 200 editions.

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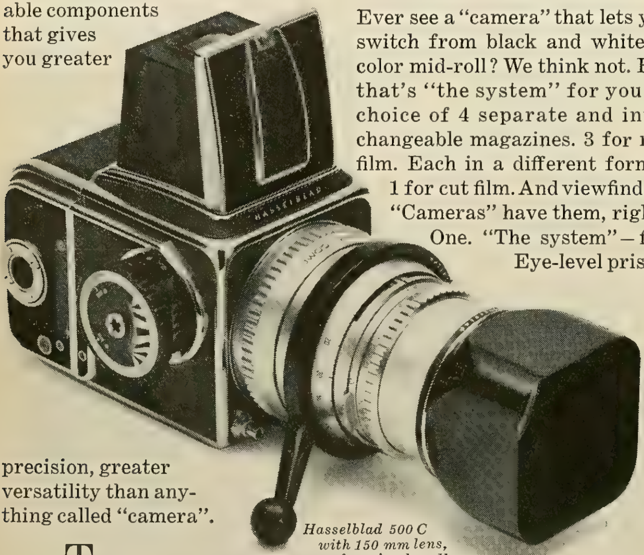

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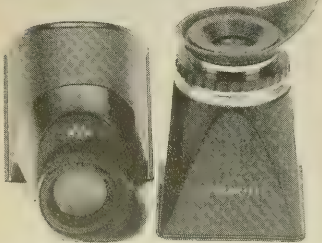

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*Timothy Galfas, noted New York editorial and fashion photographer, with "the system."*

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climate." And he says, in the study of insects "there is room not only for abstract mathematical thinking but also for the warm intuitiveness of the gardener, the hunter and the observer of living animals."

In the bibliographical appendix are references of interest to the general reader and to students of entomology.

The illustrative material in Lanham's book (diagrams and black-and-white photographs) is adequate, although some is wanting in quality and detail.

Both authors bring in contemporary research. However, even though adequate accounts are given of Karl von Frisch's classic work on the language of bees, no mention is made of the recent research by Harold Esch at the University of Munich and Adrian M. Wenner of the University of California, in which each scientist has independently found that honeybees also transmit information by means of sound.

The books have much in common. They are well written, entertaining, highly informative, and easily read. Both are relatively short, yet the authors have summarized an unbelievable amount of information without sacrificing necessary and interesting details. A remarkably lucid coverage of up-to-date information on insects has been accomplished in a scholarly and popular style.

*Dr. Radinovsky is an Assistant Professor at Millersville State College, where he is involved in research on the biology and the behavior of insects and mites.*

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WEEK IN YANHUITLÁN, by Ross Parmenter. *The University of New Mexico Press, $5.00; 374 pp., illus.*

To write about travel is an ancient literary exercise. Most travel books concern many places, with the traveler remaining the fixed quantity across whose inner screen there pass a great variety of scenes and people. Some travel books take the reader to only one place, like Alexandria or Rome or London, and the interest arises from the confrontation of a many-sided place with a single sensibility. But Ross Parmenter has invented a new sort of travel book: the registering eyes and mind travel to an old building—to live in it and to report upon the transformations, changes, and alterations brought about in the traveler himself by his stay.

The Canadian-born author was with *The New York Times* for thirty years until his recent early retirement from his post as music editor. For many years he vacationed in Mexico, not as a casual passer-by, but always with a deep concern and interest for the places and people he visited. During many visits he acquired an ethnologist's knowledge of the people and an art historian's understanding of colonial buildings and of pre-Columbian antiquities in Oaxaca.

The Dominican Church at Yanhuitlán was built between 1550 and 1570. It is among the largest Spanish buildings in sixteenth-century Mexico and when Parmenter first saw it in 1948 from a bus on his way to Oaxaca, he thought it was a dam. Fascinated by its place and meaning in the history of Mexico, he returned in 1953 and lived in the empty monastery for a week, as the guest of the government caretaker and his wife. In these readable chapters he tells many interesting things about the building itself, about the people and the children of the town, and about his own mental processes while seeing and drawing the rich, ruined architectural forms that illustrate his text. Every line, in drawings and in text, is a discovery by the author, of himself and of his subject.

GEORGE KUBLER
*Yale University*

WILDFLOWER PORTRAITS, by Eloise Reid Thompson. *University of Oklahoma Press, $15.00; unpaged, illus.* THE ODYSSEY BOOK OF AMERICAN WILDFLOWERS, text by H. W. Rickett, photographs by Farrell Grehan. *The Odyssey Press, $12.95; 252 pp.*

Mrs. Thompson's *Wildflower Portraits* were begun thirty-four years ago when she married and moved to Texas, where she was so impressed with the wildflowers that she could not resist her desire to paint them. The result is one hundred carefully executed paintings of the flowers she found, whether indigenous to Texas or not. These are reproduced life-size and with good color quality. Her use of a white background, except in cases of white flowers, sets off the delicate detail of the paintings.

The brief botanical notes contributed by Edna Wolf Miner are precise, and she interprets the botanical name of the plant as well as giving its popular name, its distribution, and its chief structural characteristics. However, the text suffers from occasional editorial oversights, for example: the species of *Lobelia cardinalis* is capitalized and *Anisostichus capreolatus* is misspelled.

Insofar as this book does not attempt to be a reference work for the flowers of the region, one can commend the clarity of Mrs. Thompson's paintings and Mrs. Miner's accompanying text.

*The Odyssey Book of American Wildflowers* describes wildflowers that grow in different parts of the United States. The book does not pretend to give thorough coverage to any particular region and thus does not serve as a reference manual. Dr. Rickett states that "to know all the wildflowers of North America is a formidable task even for the profes-

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sional, and to describe and illustrate them would require a set of books. . . . The photographs and text embrace most of the colors and shapes and sizes of our wildflowers."

The text is carefully executed and gives careful descriptions of vegetation types, families represented, and structures of the plants photographed. But the arrangement is confusing, and the reader often wastes time hunting for a description of a photograph. In some cases the pictures bear only numbers without captions.

Many of the photographs are disappointingly hazy and are often faulty in color. White flowers are almost invariably pale blue in the pictures, and the pale pink "calico" flowers of the mountain laurel (*Kalmia latifolia*) are also blue. In many cases the leaves are either not shown at all or are so out of focus that their shape cannot be seen. This is particularly disappointing where they are important in identification. There is no scale reference in the pictures, and in some cases the smallest flowers appear largest—*Cerastium oreophilum*, as shown, is an inch in diameter, while the larger head of *Coreopsis tripteris* is less than one-half inch.

This is a frustrating book to review as the first reaction is to admire the artistic nature of the photographs (those of the cacti, incidentally, are excellent), but one is constantly irritated by confusion and lack of botanical detail in the pictures. The clear and precise text compensates to some extent for the botanical weakness of the photographs.

ELIZABETH SCHOLTZ
*Brooklyn Botanic Garden*

BURTON: A BIOGRAPHY OF SIR RICHARD FRANCIS BURTON, by Byron Farwell. *Holt, Rinehart & Winston, $5.95; 431 pp., illus.* LIVINGSTONE'S AFRICAN JOURNAL: 1853-1856, edited by I. Schapera. *University of California Press, 2 vols., $11.50; 495 pp.*

BYRON FARWELL'S *Burton* is the biography of a remarkable man—British consul, explorer, orientalist—loathed and detested by many, but one of the truly great men of his era. This book is a compelling exposition of a fascinating and complex character, as well as a fine descriptive account of the more notorious of Burton's many wild escapades in different parts of the world. *Livingstone's African Journal: 1853-1856*, on the other hand, is a scholarly edition of notes kept by Livingstone himself during his exploration across south-central Africa, about which he wrote more fully in *Missionary Travels and Researches in South Africa* (London, 1857). The *Journal* does not duplicate the latter work and has the authentic ring of a personal account, not intended for publication, kept daily by a great and humble man in the midst of one of the greatest feats of exploration of all time.

Burton was far from humble, and for this reason alone his biography makes particularly good reading with Livingstone's *Journal*. The book is typical of the more extravagent side of Burton's nature, for it is full of quotations showing his gross generalizations, opinions, and prejudices. He is for toothpicks, and against education for Negroes, and is also generally antipathetic (to put it mildly) toward "Jews, Americans, Irishmen, negroes and missionaries of any nationality or faith." But this is also an indication of the difference between Burton and other explorers of his age, for Burton was not content to explore only places; his travels were also of the mind and spirit. In spite of a wild childhood, vividly described by his biographer much as a jovial social worker might describe one of his more intractable juvenile delinquents, Burton became a perceptive scholar and linguist and adopted in succession, with every semblance of sincerity, the religion of the Hindu, Moslem, and Sikh. He also had a go at both Protestant and Roman Catholic versions of Christianity, but these never seemed to sit as well with him as the oriental faiths.

He had a penchant for translating the more erotic oriental writings, and indeed one suspects that this is why he took such pains to master so many languages. His original writing is certainly not of the highest quality; the biography mercifully spares us all but a few well-chosen short excerpts.

Burton's travels took him through Africa, the Near East, India, and South America. He was constantly on the verge of the fame and glory he sought, and which he certainly deserved, yet it always eluded him. Behind him at all times we see his enigmatic wife, strangely prudish for a man with such exotic tastes, slavishly devoted, passionately possessive. After his death, she became the subject of brutal attack through her burning of many of her late husband's manuscripts, those which she deemed unworthy of publication, or which she imagined might have proved too spicy for the good of Burton's reputation.

One would expect to find Livingstone's *Journal* dull by comparison, but it is by no means so. The excitement and drama are more subdued, the exotic setting less gaudily portrayed than it would have been by Burton, and the observation of "native customs" considerably more restricted. In fact, as the editor, Professor I. Schapera, points out, as an early source of descriptive ethnography Livingstone is most disappointing. One of the great merits of these particular travels was the extraordinarily precise and

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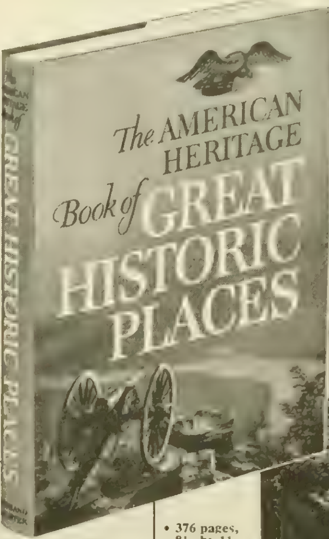

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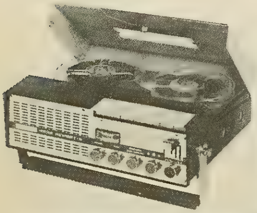

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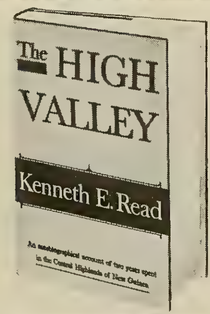
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accurate geographic record kept by Livingstone, who was, after all, primarily a missionary seeking a suitable site for a mission station and a suitable means of access to that site. It seems almost incidental, from Livingstone's point of view, that to achieve this goal he had to travel overland from south to central Africa, across the Kalahari Desert; then to the west coast, back to central Africa, and finally over to the east coast.

But for those who think of Livingstone primarily as an explorer, the *Journal* reveals, better than his published account of the same explorations, that he always considered himself first and foremost a missionary. To him, his travels were an opportunity to spread the Gospel, and we see how from one day of hardship to the next this man never lost a chance to preach Christianity. Unlike Burton, Livingstone's accounts of his travels are matter of fact—almost offhand. So marked is the absence of any tendency to romanticize that the inherent drama keeps eluding one, and the reader has constantly to remind himself of the epic nature of the occurrences.

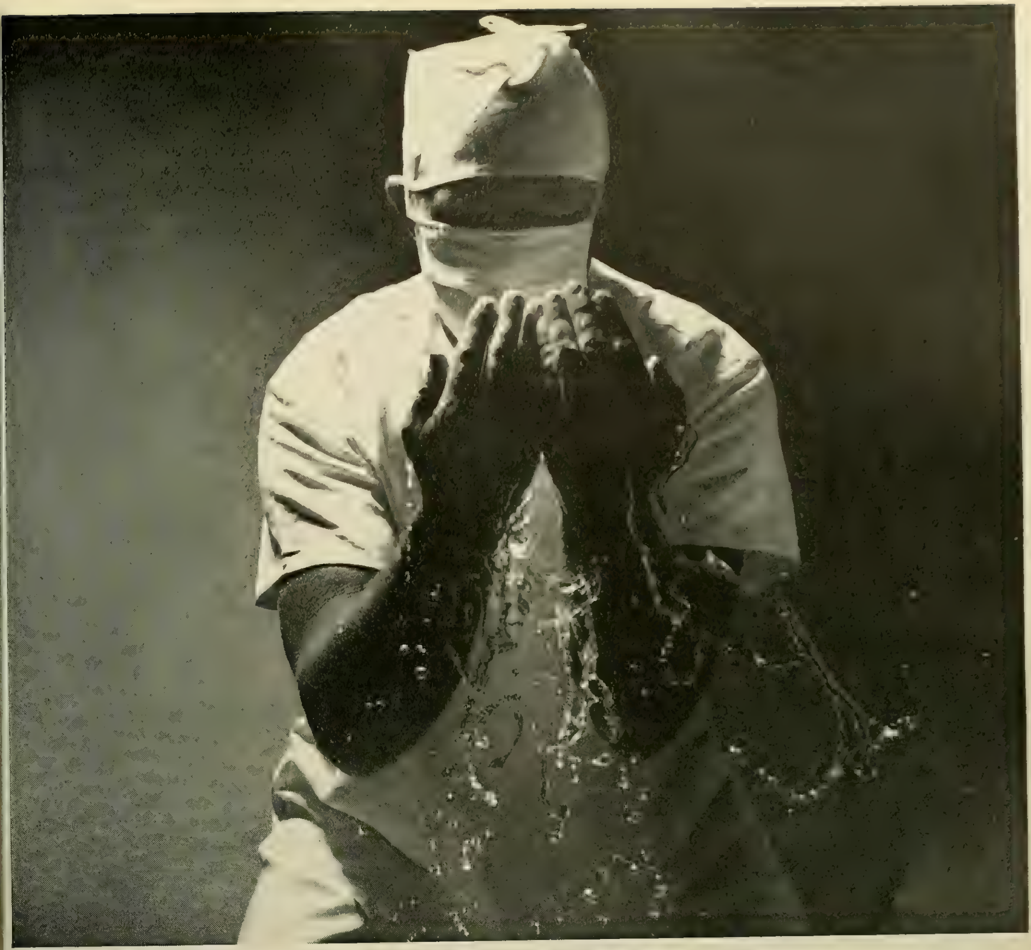
It would not be true to suggest that the *Journal* (in two volumes) is as easy to read as the biography of Burton. It is hard to put the latter down, whereas the *Journal* can be picked up and read a little at a time. Nonetheless, the *Journal* is a firsthand account, edited by an eminent and sympathetic Africanist who restricts himself to an all too brief but pertinent introduction, and to making occasional and revealing contrasts between the *Journal* and the popular *Travels*. It also benefits from being limited in space and time, so that here one has a chance to see the workings of the mind of a great explorer, whereas Burton's biography is a broad overview.

COLIN M. TURNBULL
*The American Museum*

BIRDS OF PREY OF THE WORLD, by Mary Louise Grossman and John Hamlet, photographs by Shelly Grossman. *Clarkson N. Potter, Inc., $25.00; 496 pp.*

THIS large and handsome volume treats all the eagles, hawks, and vultures of the world; all the condors, kites, buzzards, harriers, caracaras, and falcons; the osprey and the secretary bird —and for good measure, all the world's owls. It is an astonishing undertaking and a considerable accomplishment, particularly since the authors are not professional zoologists. The book has a cultural, rather than a zoological, approach and will find devoted readers among naturalists and wildlife admirers in general, and in particular among those of us who find a fascination in eagles and falcons beyond common understanding.

Shelly Grossman's spectacular photographs of captive birds of prey are the



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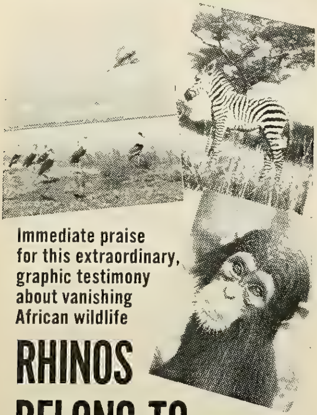

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[1] Manchester Guardian

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inspiration of this work, and the first half is a series of large color photographs supported by five chapters of well-written and informative text ranging over the historical, cultural, biological, and ecological aspects of these birds. John Hamlet, an old-hand falconer and keeper of birds of prey, assembled an extensive collection from all parts of the world at Ocala, Florida. The portrait photographs of some of these are superb, such as those of the condor and the white-headed vulture. Eric Hosking and Heinz Meng present excellent views of imperial eagles and goshawks in the wild. Other photographs of unpreened or poorly plumed birds, unavoidable in zoological park collections, are often interesting and sometimes show particular features, but too frequently are poor as book illustrations.

Most arresting and unusual is a series of large close-up photographs of hawks attacking prey, an attempt at contrived predation understandably controlled as to subject and sequence. Included is a grotesque series of a great horned owl wrestling with a very large snake, a young red-tailed hawk battling an opossum, and a diminutive American kestrel struggling with prey at the upper limit of the possible. Such things can and occasionally do occur in nature (as when a juvenile golden eagle attacked a dog in a Chicago street), but they are far from usual and do not help to explain predation to an unsophisticated public. Sportsmen and ranchers often believe that eagles live upon six-point bucks and livestock, failing to realize that such occurrences take place only when the hungry predator cannot find a vulnerable prey of appropriate size.

To my mind, the text chapters in the first half of the book are the best part of the whole work. They present many cultural relationships of birds of prey that I had never come upon, and the authors have come up with new and interesting facts and pictures that are a pleasure to read and admire. The biological sections are thoughtful and well informed. The authors clearly state that many important predators are threatened by the accumulated insecticides in the food chains that support them. This fact seems to be responsible for the drastic population declines in such birds as peregrine falcons, eagles, and some hawks.

The second half of the book is approached entirely differently; it is an inclusive survey of most of the diurnal and nocturnal birds of prey, complete with range maps and notes on particular habits. It is chiefly illustrated by the underwing flight diagrams of all species of Falconiformes after the manner of May, Brooks, Weber, and Peterson. There is no comparable book written for the general naturalist, and the authors have produced an astonishing number of facts and figures. This second half might well have been printed as a separate book, perhaps in smaller format. There is also a wide-ranging and selective bibliography.

Walter R. Spofford
*State University of New York*

Home is the Desert, by Ann Woodin. *The Macmillan Co., $5.95; 247 pp., illus.*

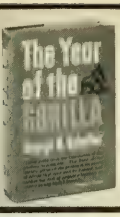
This is a book about living among the wildlife of the Sonora Desert of Arizona. It is excellent. In an introduction, Joseph Wood Krutch has this to say of the author (and Mr. Krutch hits the nail on the head): "I know of no one who takes fuller or more joyous advantage of precisely those special attractions which life in this region affords. Doing that means a great deal more than merely liking nature in some vague way. It means combining aesthetic appreciation and intelligent curiosity with something harder to define which I can only call an emotional rapport."

The Woodins (he is a scientist and Director of the Arizona-Sonora Desert Museum) live amidst an incredible mélange of bipeds, quadrupeds, "nopeds," and various airborne species. So, you may say, do all of us. But the difference here is that they are all under one roof, the Woodins', which must be precariously supported in view of the many species that apparently crawl in and out from under it with no trouble at all.

In writing about a situation of this sort, it would be easy to succumb—as so many contemporary writers have—to the temptation to be folksy or cute. Not so with Mrs. Woodin. She is too sophisticated. Rather, with wisdom, well-controlled enthusiasm, and considerable knowledge, she explores not only the specific aspects of her desert environment, but the total effect of that environment on the mental and spiritual development of her family. There is nothing pretentious or heavy about this last; it is only when you get to the end that you realize that this, really, is what the book is all about.

In saying this, I don't mean to discount the interest or value of Mrs. Woodin's specific observations. One of these, however, disturbed me for a moment. She tells of rinsing her hair in the bathroom sink and seeing in her mirror the eyes of a small tree frog that unbeknown to her, was sharing the plumbing facilities. "We stared at each other for a few seconds," writes Mrs. Woodin, "and then I removed my head." Evidently, this self-inflicted decapitation has not impaired Mrs. Woodin's ability to get around, or to write. One may hope to hear more from her in the near future.

Pieter Fosburgh
*Author and Editor*



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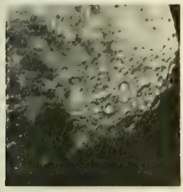

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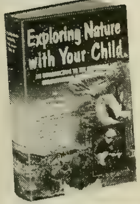

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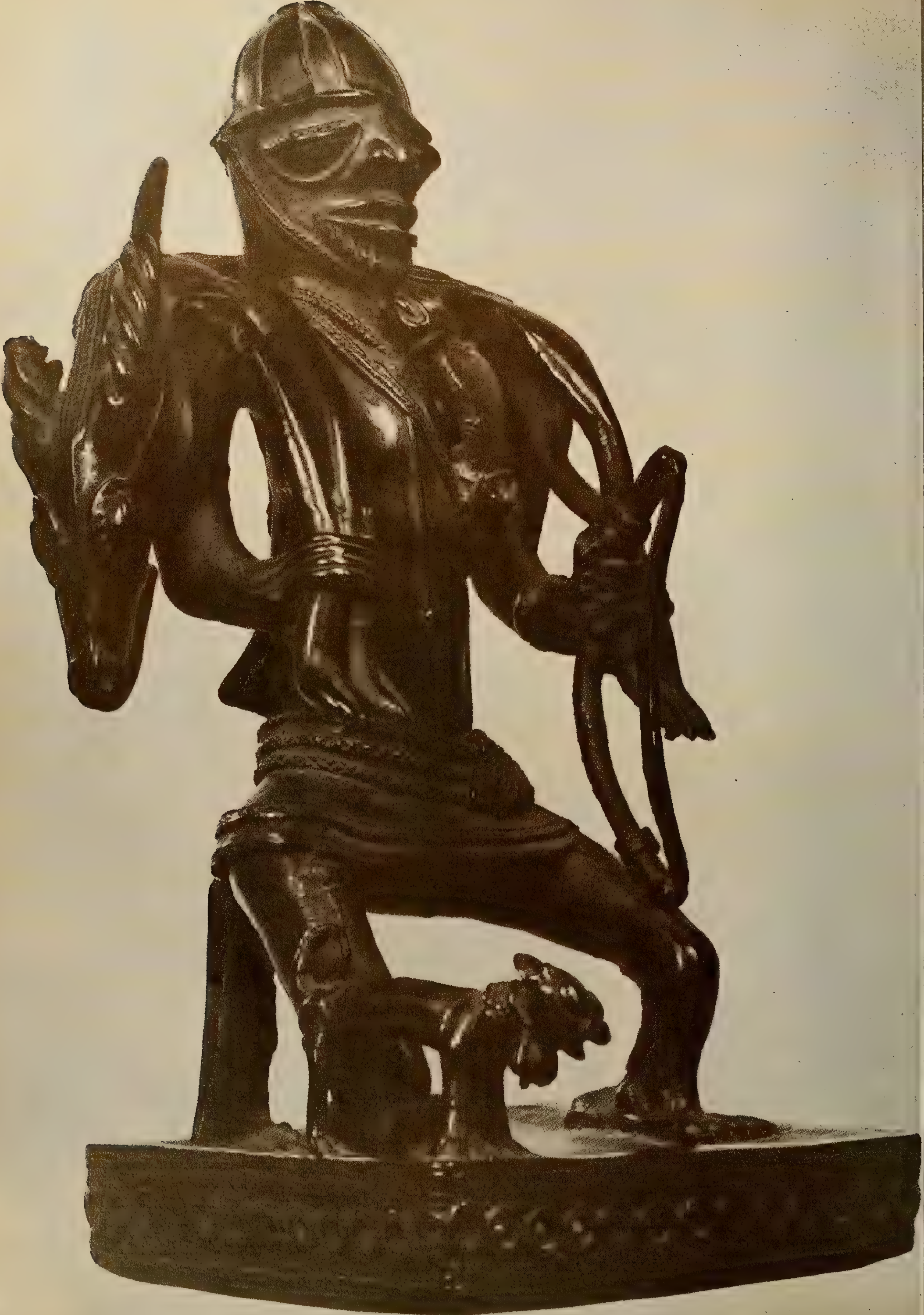


## THE ART OF LOST-WAX CASTING

# Men, Beeswax, and Molten Metal

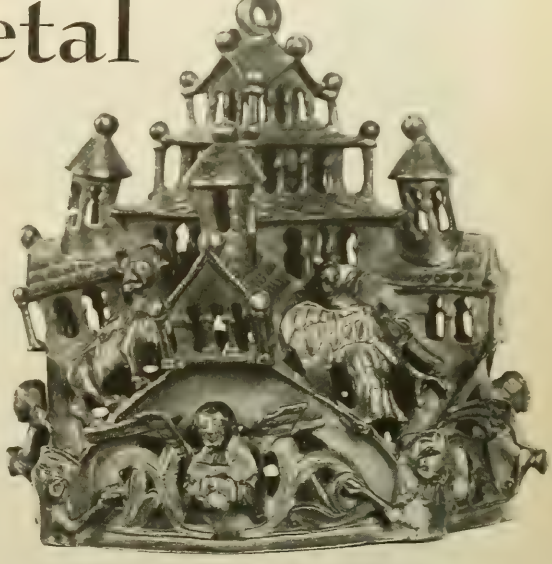
### by PAUL J. BAUS

Consider that before history, at the various times and places that man discovered metals and how to melt them, he also knew the technique of burning clay to form ceramic and was eating wild honey and brewing it into mead. With the beeswax of the honeycomb his magicians must surely have modeled images for magical purposes, and such images would have had the wonderful property of taking forms from this world to the next when sacrificed in fire.

If the magician packed clay around the wax image that was to be sacrificed and put it into the fire, the wax melted and escaped to the other world, but left its impress—a mold—with this world inside the lump of fired clay. It was then found that if a small, molten river of bronze, silver, or gold was allowed to run into the ceramic cavity, it precisely replaced the forms that had been modeled in wax. The ceramic mold and its metal nugget cooled. When the magician broke the clay, the metallic transformation of the image remained, another proof that all the world was magic.

This suggestion for the origin of the lost-wax, or cire-perdue, process of metal casting is speculation, of course, but these three things that early man knew about and used—wax, ceramic clay, and molten metal—were probably associated in some such way to create the technique of lost-wax casting. As it was practiced by early man, the method had a versatility and simplicity that contrasted with the limitations of what were probably his first foundry processes—casting into molds of stone and sand. In these qualities of the lost-wax process, perhaps, rest some of the reasons for the merit of most early lost-wax sculpture.

Early in any metalworking age, casting became an important method of forming metals, partly because it was more convenient than hammering metal into shapes. Casts, of course, are made by pouring molten metal into molds of fireproof material where it cools and solidifies. Stone molds from the Bronze Age, for casting simple spear points and axheads, were made by carving half of the negative impression of the tool to be cast into a plane surface of each of two stones. The impressions were aligned, the stones were held firmly together, and metal was poured into the mold cavity they formed.

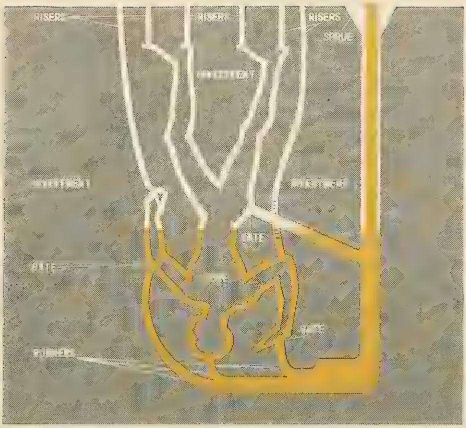


*Late 12th-century German censer shows the complexities of design possible through use of the lost-wax process.*

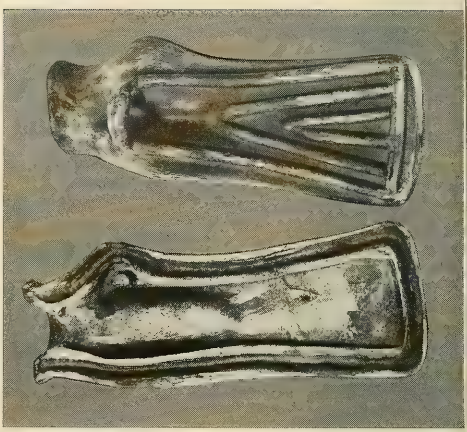
*Discovered by the British in Benin, this work was cast in Africa before the advent of 16th-century Europeans.*

The same result could have been achieved by firmly packing fine, moist, loamy sand around some tool used as a model for the tool to be cast—like a dragonfly that has been the model for its own fossil. It was only necessary to form the sand in two sections so that the mold could be opened and the model removed. Even though direct evidence of the fragile sand forms will not be found, one can be sure that they were also in early use. This same technique is still employed today, and with it much industrial metal work and some metal sculpture are produced.

A stone mold could have been used over again if it had no undercuts that made its breakage necessary for freeing the cast. On the other hand, such undercuts in the model for a simple sand mold prohibited its use in the first place, because the packed sand would break when the mold was removed. Thus, certain com-



*Drawing shows method for pouring metal from crucible into mold cavity between the core and the investment.*



*Inside (bottom) and outside of Swiss Bronze Age stone mold is made in two pieces for duplicating bronze celts.*

plex forms were impractical with either process until there was a further development of technique. Today, complex molds for intricate shapes are made of many pieces of packed sand, but this work requires great skill, and there are limits to the detail that can be reproduced with fidelity.

On the other hand, the discovery of the lost-wax process made it possible to cast any form the sculptor wished to produce. Each bit of wax that he added to the model, whether twisted, pinched, or scratched, was precisely reproduced in metal. By simply investing the model carefully in plastic clay he made a perfect mold that needed little more attention. It was not necessary to divide the clay to remove the model—the wax was simply melted out. And it was not necessary to conceive the design in reverse and arduously carve it, as was necessary with stone molds.

Melting and casting techniques may well have been invented by each culture that came to use metals, although some archeologists believe the knowledge was discovered once and passed from one part of the world to another. In any event, in such places as Egypt, Crete, the land of the Hittites, the Indus Valley, and Shang China, widely scattered peoples began to cast metals and to use the lost-wax process during the third and second millenniums. These skills seem to have spread rapidly around the world, and during the first millennium the later Greeks, Etruscans, Persians, and several other European and Asiatic peoples also worked in this fashion. In the eighteenth and nineteenth centuries, when Europe divided central Africa, it was discovered that a number of peoples were founding with lost-wax: the Ife, the Yoruba, the Bini. Today a few of their descendants still use the comb of the honeybee to mix with the magic of clay, fire, and old telegraph wire to create lost-wax sculpture.

Even in the New World, when it was discovered by the Old, several cultures were far advanced in metalworking. The excellent and egotistical Italian Renaissance sculptor Benvenuto Cellini wrote in the sixteenth century that he had perfected lost-wax founding. But in the years when he began to work as a sculptor, about 1520, Spanish ships were beginning to bring the gold hoard of the New World to the ports of Europe, and much of that wealth was taken from its original owners in the form of lost-wax castings. It is probable that the gold Cellini poured from his crucible to cast the saltcellar for Francis I of France contained the melted remains of lost-wax masterworks from Peru and Mexico.

Although the principle of lost-wax founding seems to be simple, and a wealth of good castings exists from many early periods, the craftsmen had to solve a number of technical problems. A progressive series of demonstration molds from African tribal work, now in the British Museum, shows how some of the problems were solved intelligently in primitive conditions. The founder first pressed clay over his wax model, shaping it like an open-mouthed jug filled with wax. He then modeled another clay jug, this one a crucible that was hollow except for bronze ingots put inside while it was being made. These two juglike forms were placed mouth to mouth and sealed together with more clay. This made their interiors one dumbbell-shaped cavity that was pinched where the necks joined. The entire unit was then placed near a fire, crucible end down, and the whole was heated slowly to melt the wax and dry the clay. When the clay was dry it was put in the fire to burn out the wax, and the vapors of the burning wax escaped through the porous clay. The mold-crucible unit was heated further until the clay and the metal it contained were above the melting point of bronze. Then the unit was inverted by gripping it with a doubled green stick, used as tongs, and the metal ran from the crucible into the mold.

Although this was an unusual method, the basic foundry problems have been the same in all ages—one must embed the model in investment and yet have an appropriate opening from which to lose wax and through which to pour the metal. The solution is to weld a rod of wax to an inconspicuous part of the model and to extend this rod so the end of it will be exposed on the outside surface of the investment after it has been placed around the wax. Then, when the wax is later melted from the investment, a channel to the mold will have been formed. If this rod is enlarged into a cone as it comes to the surface, a funnel remains, as the wax melts, into which the molten metal can be poured. This funnel is called the sprue, and the path from the sprue to the mold cavity is the runner. The point at which the runner enters the mold cavity is the gate, and the system through which metal flows into the mold is called gating.

If one likens the gating and mold cavity to a funnel in the mouth of a bottle to be filled with water, the next problem can be anticipated. The water that flows into the bottle must displace an equal volume of air. If the funnel is sealed to the mouth of the bottle, as the sprue is sealed to the mold cavity, the air must rise within the water that flows down through the funnel. Such bubbling greatly impedes the flow of a liquid, and liquid metal could cool enough to congeal before taking the impression intended for it. In addition, the mold for a design may have parts in which air could be trapped to prevent metal from filling them.

Since the speed of filling the mold is important and entrapped air must be avoided, vents are provided for the air that the metal should displace. These are called risers, because they allow the air to escape as it rises on top of the metal filling the mold. Thus, the metal should enter the bottom of the mold first, and this is made possible by attaching the runners to the lowest points of the mold so that the metal will fill it while rising. The risers are provided at the time the sprue and runners are attached to the model, and are also made by welding rods of wax to the highest parts of the model and having them extend to where the top, outside surface of the investment will later be.

The complete unit of wax, then, that will form the mold and passageways for metal and air, is made up of the model of the sculpture, the sprue, the runners, and the risers. These are all welded together according to the logic of how metal can best flow into the mold to become sculpture, and how air can escape from the mold to permit this.

The material of the investment is then selected or compounded for important qualities. Among others, it must be able to make a good impression of the

*Of ornate design, this golden saltcellar made by Cellini may have been cast of metal melted from other sculpture.*

wax, and the resulting mold surface must withstand the heat and rushing force of heavy molten metal. The investment is placed around the wax, and it is built up to form a considerable bulk, giving the mold strength to resist the hydraulic pressure of the metal.

After the investment has dried to become a firm, hard, solid substance, the mold is complete except for removing the wax model. To do this the unit is placed in a kiln; first, to melt the wax so that it can run out, and next, to burn away all wax or moisture that may remain. Any substance in the investment that hot metal can vaporize will quickly expand and be explosively dangerous. In order to avoid the possibility of accidents to the work or the founder, the investment is usually buried in packed sand just before metal is poured into it. The moment of pouring the metal is crucial. The sculptor's original work has been destroyed, and, if he designed in wax, as early sculptors did and some do still, all that remains is the mold.

A strong, heat-resistant crucible is in the furnace, full of liquid metal and glowing at a bright, incandescent heat from the speed with which forced air burns the fuel. The fire roars. When the pitcher of liquid metal is enough hotter than its melting point so that it will not freeze before reaching all of the details of the mold, the forced air is stopped. The furnace is quiet, the crucible is lifted out with tongs and taken to the investment. The heavy, liquid metal is poured in a large, quick, steady stream into the sprue until the mold is full. The riser-holes show dots of light where the luminous metal rises in them, and the sprue holds a little glowing pool. Then the metal cools and freezes to a ruby red, to a dull red glow, to black. The sculptor's work has been reborn in fire.

After the cast is cool and the investment broken off, there still remains work to be done. The attached gating must be sawed off and the surfaces destroyed by these attachments must be reconstructed. Then, too, the sculptor may rework all of the metal surfaces —a process called chasing, which consists of chiseling, modeling with punch strokes, grinding, and polishing. In addition, as with their other mediums, the sculptors of the past added colored and gold and silver surfaces, and inserted ivory, shell, and jewels for details such as eyes, ornaments, and clothing.

A modification of the small, solid metal casting implied up to now had to come when man attempted larger works for more complex societies, such as the Archaic Greek. Larger, more solid casts present serious problems; they require too much heavy, expensive metal, and they become distorted by shrinkage when the liquid metal cools. Although a certain amount of distortion from shrinkage can be prevented by providing reservoirs to feed more molten metal to the cooling, shrinking, and yet liquid cast, there remain the problems of weight and cost. A cubic foot of bronze, 10 per cent tin and 90 per cent copper, weighs about 550 pounds—approximately three times the weight of granite—and would cost, at today's average wholesale prices for copper and tin, about $280.

But the best solution to the problems of shrinkage weight, and cost is to cast sculpture as a thin, hollow shell. In Greece and Etruria, by the sixth century B.C., this was achieved by building a core of clay or other fireproof material, smaller than the eventual sculpture by the thickness that the cast was to be. The future thickness of the metal was then determined by the thickness of a layer of wax, which was placed over the core and in which the sculpture was modeled. As a result, a life-size figure, cast hollow in bronze, might have a wall thickness of about a quarter of an inch. Because bronze has enormous tensile strength, sculpture made in this way is strong. One sixth-century B.C. bronze figure of a Greek athlete, a *kouros,* standing six feet four inches high, is an example of sculpture probably cast in this way.

In principle, lost-wax founding is the same today as it was in the distant past, although the modern founder uses a greater variety of investment materials and waxes, and some added techniques. An influential process developed since the Renaissance has permitted the founder to cast a design in any medium by lost-wax. He can, and now often does, begin his work with a plaster cast of the design that the sculptor gives him. From the plaster cast he makes a flexible mold of rubber, glue, or agar-agar, and in the mold casts a wax version from which to begin the lost-wax process. Except with the smallest designs, he makes the wax cast hollow, packing the core inside it.

Because the founder can cast his own wax model and the core as well, the sculptor no longer needs to design in wax. He has a free choice of materials in which to develop his design, and he most often uses modeling clay. From the fragile clay design, a plaster cast is taken for the founder to use. Then, should the founder have an accident in casting, the sculptor no longer has to fear the loss of all of his labor, as would have happened if he had modeled directly in wax for casting. The plaster version of the design remains, and it can always be used for making duplicates.

Although any metal can be cast by the lost-wax process, bronze has been a favorite choice of sculptors for a number of reasons. The most practical of these are its important qualities of strength and workability. These qualities are also the ones that made bronze the material by which man advanced so enormously in his technical progress from tools of wood and stone to electronic tools.

The Bronze Age (different parts of the world discovered bronze at different times) began when it was found that solutions of certain proportions of copper and tin were far stronger than copper alone. We say it ended with the Iron Age, when it was found that metallic iron could be smelted from the large deposits of iron oxides that exist. Before that, metallic iron was a unique substance known in the form of meteorites.

When bronze is alloyed, raw copper is first melted, and this requires a heat just above 1980 degrees Fahrenheit. Tin is then added in chunks that liquefy at once, because the melting point of tin is only 447 degrees Fahrenheit. In the instant the tin melts, it diffuses into solution with the copper, and bronze forms as the

*Figure of the Indian deity Bhu-Devi was cast in bronze in the south of India sometime around the 16th century.*

result of a physical association, not a chemical combination. The alloy has a lower melting point and is more fluid than copper, making it ideal for casting the detail of sculpture. Depending on the proportions of the two ingredients, the metal will have different degrees of strength and different colors when it cools.

Sculpture is usually cast with a golden-colored bronze made from 5 to 10 per cent of tin, but some prehistoric bronzes contain so much tin that they have a silver color. The Romans composed an alloy of about one-third tin for their specula, or mirrors, and this speculum metal was used in the nineteenth century for the specula of early reflecting telescopes.

Bronze has two kinds of strength in rather ideal proportions: it has the tensile strength of wood and the compressive strength of stone. Bronze made possible the development of design in sculpture that wood was capable of only in the long direction of its grain, and of fragile forms that stone could not be given. Even wire and ribbon forms are possible with bronze.

The sculptor was doubly fortunate to have beeswax as a material for the lost-wax process. It made molds conveniently possible and at the same time has the physical qualities of bronze on a reduced scale. Working in wax to form the pattern for metal sculpture, one can pinch and cut the wax easily; bronze, too, can be formed—but it must be done laboriously by cold-forging and chiseling. Because of the similarity, one can weld wax with the heat of a candle flame as one welds bronze by intense heat. Also, if the lightweight wax is cool, it supports the pattern by its own tensile strength, much as the heavy bronze will later support the intricacies of the sculpture.

The advantage of bronze—that it combines high compressive and tensile strengths, making complex design possible—is almost matched by its resistance to time and weather. It corrodes slowly and produces handsome carbonates and oxides. As a result, we admire the surfaces of antique bronzes for the colorful patinas that time and the elements have given them. Antique bronzes originally had deliberately created polychrome surfaces, rather than the brilliant carbonates of copper, malachite, and azurite with which they are often covered when found. Sculptors since the Renaissance have been much influenced by the accidental patinas on antique sculpture recovered from the soil, and they have developed similar surfaces on their works by chemical treatment. An infinite variety of results is possible; burnished bronze, showing through oxides and carbonates of copper, and the play of light and shadow across bronze forms can produce handsome effects, some seemingly translucent.

The ancient process of using a wax model is so versatile that there is almost no limitation to the shape or surface texture that can be cast into metal by means of it. In the past it was used to cast the bronze bells of churches, giving them their inscriptions and surface ornament, and until the time of Napoleon some of the finest, most highly decorated military ordnance was cast by the lost-wax process. It is still important for casting metal sculpture, and it is also important for other work that requires precise castings of involved shapes, such as those for machinery and dentistry.

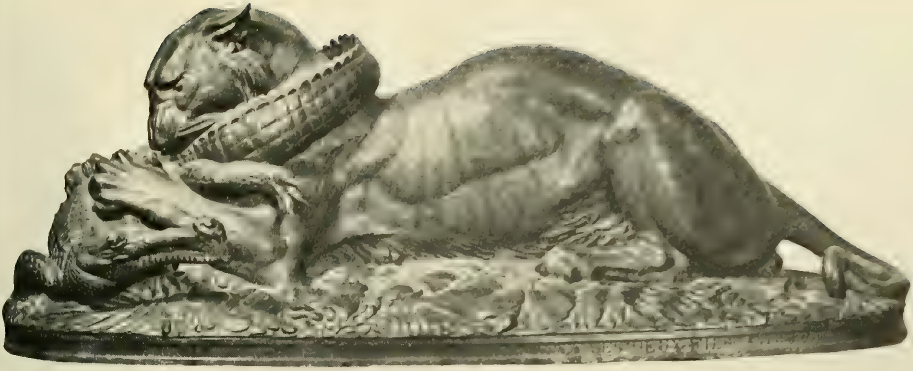
From the late Renaissance until recent years sculpture casting by lost-wax was confined almost wholly to art foundries that specialized in working for sculptors. Earlier, sculptors had assumed the responsibilities of founders too. For instance, Lorenzo Ghiberti spent the years between 1403 and 1424 in designing and casting the north doors of the Baptistery of Florence. Then, in the period from 1425 to 1452, he designed and cast "The Gate of Paradise," the east doors of the same Baptistery. On the other hand, nineteenth- and twentieth-century sculptors have usually turned their work over to someone else to cast. Rodin, for instance, had much of his work done by the Parisian founder Alexis Rudier. Today, believing that sculpture will be better designed if the sculptor is also a founder who knows what is possible with the medium and has more control over it, some sculptors have their own foundries, as does Giacomo Manzu.

Sculpture is one of the arts, like poetry, music, and painting, but the crafts of sculpture–the design of form, the understanding of the forms of nature, and the manipulation of the materials in which the sculptor works—should be as well mastered by him as are the crafts of words, sounds, colors, and lines by poets, musicians, and painters. The crafts, then, are a necessary part of sculpture, but as an art, sculpture is one of the mediums with which man can think about his world and discover what this thinking makes him feel. Man no longer lives by magic and cannot be influenced by it, or so he believes, but the magic of his mind, when he is willing to let it exist, can create and induce ideas with sculpture as it can with other mediums of the fine arts. Just as these other mediums can still convey idea and feeling, so, too, bronze transformed from wax has the magic to talk to the minds and emotions of man.

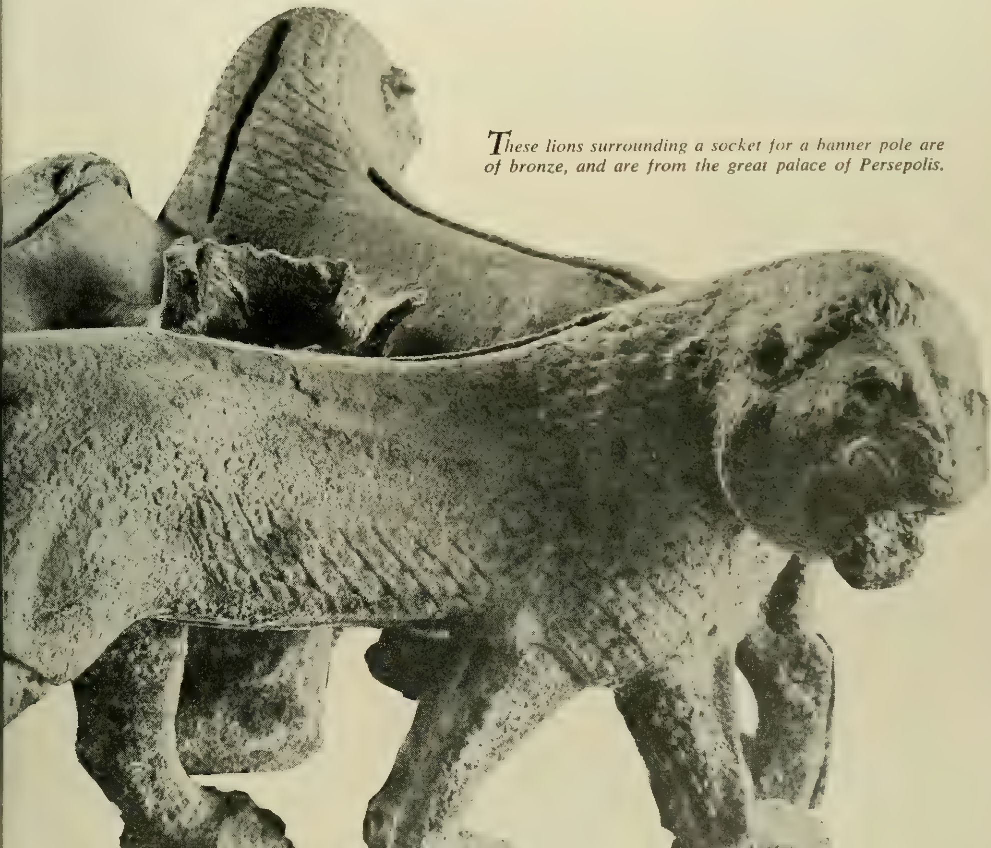
Only a short while ago any sculpture that did not exist in a style that was derived from the Greek was considered to have little, or at least less, merit. Man of the Western world complacently equated merit in most facets of his culture with Greek origins. Interest in archeology and anthropology has increasingly modified this point of view and has helped to develop an understanding that important thought and works, among them sculpture, have been produced at many times in the past, not only by the most complex societies, which we call civilizations, but also by smaller and less complex groups of people. The glib-tongued and prejudiced have often called these simple groups "savage" and "primitive." But the wise person will not judge the merits of another only by making comparisons that use himself or his culture as a standard. Are our thoughts–religious, political, poetical–superior to those man had ten or twenty thousand years ago? Many of us would still like to believe that they are, because we each count ourselves as members of a civilization that we think is superior to any in the past, and to a great extent we base this judgment of superiority on complexity.

Seeing superiority in complexity, many have assumed that Aurignacian man, who painted animals in his cave, or the Eskimo, who sculptured animals, was inferior to us in his art. These so-called primitive peoples used more simple techniques, and perhaps more simple ideas. They did not have the world and as much of its history as we to draw upon both for technology and idea; but surely their work is not inferior for this.

The quality of thought, belief, and feeling, not the complexity, may be a better standard for the measure of man's worth and thus the worth of his art. Sculpture has been a medium for those elements since long before man's written history, and his literal digging into prehistory has helped to recall his past. Because they are less complex, the older techniques–the result of individual man's experimental manipulation of the materials which confronted him—are thought by some persons to provide the most logical mediums with which the sculptor can develop and display quality of mind to discover what man is. It is with this logic that sculptors have returned to the simpler methods of working directly in stone and wood, and more recently to direct modeling of wax for lost-wax sculpture.



*Bronze casting of Antoine Barye's "The Tiger and the Gavial" reflects 19th-century scientific interest in nature.*



*These lions surrounding a socket for a banner pole are of bronze, and are from the great palace of Persepolis.*

# Mechanics of a Turnover

## BELL CONTRACTIONS PROPEL JELLYFISH

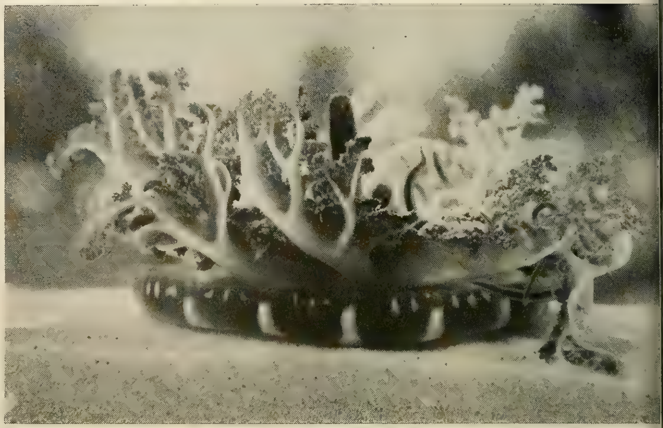
by VIRGIL N. ARGO

The coelenterates—including the corals, sea anemones, and jellyfish—belong to one of the most primitive animal phyla, and would have fared badly in the biological struggle for existence had they not evolved a most intricate and efficient survival device—the nematoblast, or stinging cell. This explosive ectodermal cell can, on contact, irritate, paralyze, or kill other animals that are often of much greater bulk than the coelenterate itself.

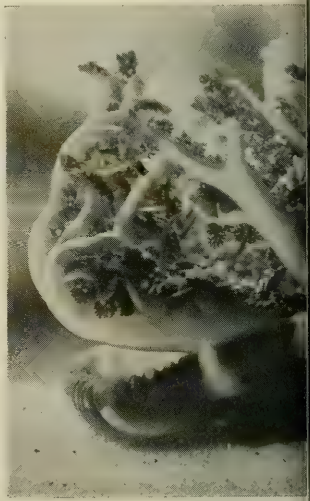
Coelenterates are made up of only two body tissue layers, ectoderm and endoderm. Capable of only simple, diffuse muscular activity through contractions of scattered muscle cells, they have never evolved agile, rapid locomotion to serve as a survival mechanism. Some, such as the corals, get along very well without any locomotion at all, and others, including sea anemones, manage with locomotion so slow as to be best observed by time-lapse photography. Still others, such as the jellyfish, swim slowly. None of these animals hustle about seeking food, because their stinging cells and body symmetry enable them to live without fear of possible competitors while they await potential food that may come from any direction.

The coelenterates occupy a lowly position in the scale of evolution, but they have accomplished marvels with the materials they have had to work with. They seldom cause trouble to humans except, perhaps, an occasional bather who collides with one of the larger jellyfish or a Portuguese man-of-war, or a diver who might abrade his skin on the limy skeletons of corals on a tropical reef. All the coelenterates are interesting to look at, and they sometimes exhibit striking beauty of color and form.

I encountered my first *Cassiopeia* jellyfish a number of years ago while wading through the shallow water of a mangrove-bordered tidal lagoon on the outskirts of Key West, Florida. At first glance they seemed to be some sort of sea anemone. To investigate further I pushed one with the leg of my camera tripod, and the creature began a series of convulsive contractions, turned itself over, and then began rhythmic contractions of its bell, or umbrella, and propelled itself away. It swam in the most orthodox type of jellyfish locomotion—with its bell on top and mouth below. After a short swim it settled down, turned over again, and was seen to be a truly "upside-down" jellyfish. What at first had appeared to be a great mass of tentacles was actually a broad cluster of many-branched outgrowths of its manubrium—each outgrowth having at its extremity a minute mouth opening.

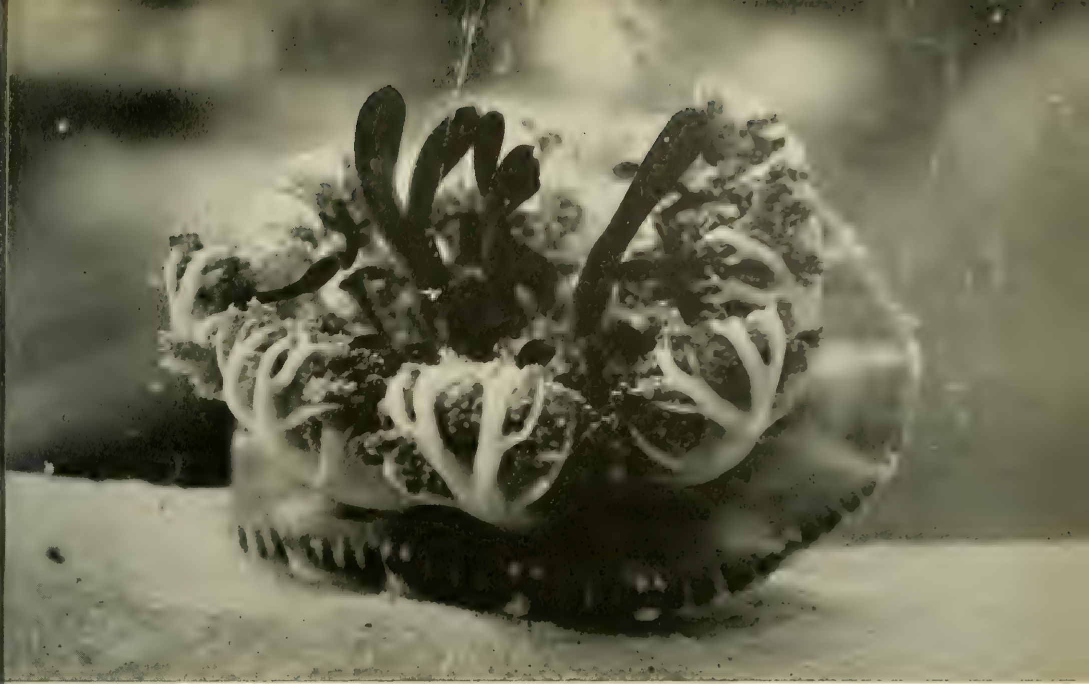


*Jellyfish,* Cassiopeia xamachana, *rests on aquarium sand, above. As animal begins to turn over to swimming position, one side of the bell rises, below, as the other side, above right, pumps down on sand.*



After righting itself into this normal upside-down position, the resting *Cassiopeia* maintained a constant series of rhythmic, circumferential contractions of the rim of its bell. These pushed its body down against the sand and held it in place against the gentle pull of the tides. These bell pulsations deflect water up through the manubrium branches and would seem to supply a constant stream of microorganisms or organic particles that can be ingested as food. (The body of *Cassiopeia* seems to weigh somewhat more than an equal volume of ordinary jellyfish body, and this higher specific gravity may help in the solution of the animal's anchorage and turning over problems.)

I later kept specimens of the *Cassiopeia* in a twelve-quart bucket for over twenty-four hours, and could



see no perceptible change in their well-being. Their oxygen needs seemed to be extremely slight, but to afford possible necessary aeration, I gently poured off the water in which they were kept into another pail and then slowly poured it back over the animals from an elevation sufficient to produce a maximum of bubbles. I repeated this process at intervals of two or more hours. The pulsations of the umbrella may have some respiratory significance, but there seemed to be no appreciable change in their rate during this twenty-four-hour period of confinement. Coelenterates have long been recognized as hosts to symbiotic, chlorophyll-bearing microorganisms that might give off a surplus of oxygen during photosynthesis and thus ease the jellyfish's requirements both for outside oxygen and for food.

These animals are beautifully colored in subdued shades of gray, blue-gray, greenish gray, or buff, which may become almost yellow. There are white markings on the rim and top of the bell, and ribbon-like lappets extend upward from among the multitude of oral branches. These dark, purplish-maroon lappets are thin, but may be up to two inches long and a half inch wide. The color markings on the different parts of the bell, the size and number of the lappets, and the abundance and arrangement of the oral, tentacle-like branches show great variation, and in any one observation one might think he is seeing a number of species or varieties. Actually, apparently only two species are present in the shallows at Key West—*Cassiopeia frondosa* and *Cassiopeia xamachana*. (The photographs here are of the latter.)

The phenomenon most perplexing to me was the mechanism of the change in orientation from the jellyfish's normal position to its upside-down position and vice versa. At first, it was not apparent just how the animal turned itself over, so I constructed an aquarium of heavy plexiglass, ten inches high, twelve inches wide and four inches from front to back, added clean sand, and filled the tank with sea water from the precise spot on the Florida coast where the animals had been collected. When the jellyfish were put into the aquarium (with a large, slotted cooking spoon), they immediately settled down on the sand in the upside-down position. I left them undisturbed for a time and then pushed them with a blunt plastic rod. Sometimes they righted themselves immediately and swam to another part of the tank; at other times they settled back into their original positions without turning over into the swimming position. If the poke was repeated, however, they would eventually swim away to avoid it.

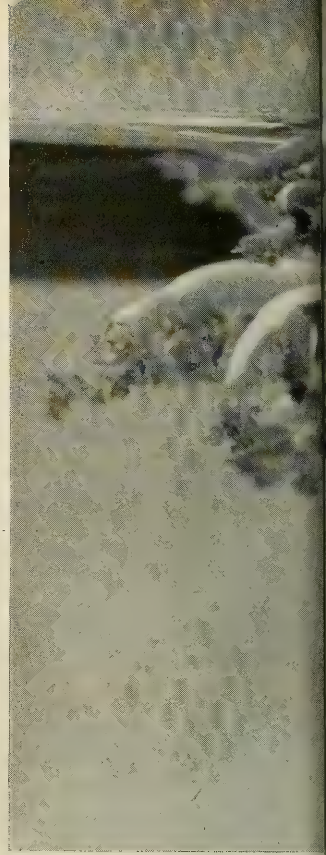
I hoped to obtain photographs that would illustrate the steps in the body turnover. Although the whole periphery of the umbrella rim contracts during the turnover motion, repeated observations showed that a more vigorous pumping force is exerted on one side than on the other. This more strongly contracting portion of the rim is pushed down and across the sand along the line of one diameter of the bell, while the opposite rim is raised until the umbrella stands on its edge. Immediately afterward, the animal starts swimming away on a fairly horizontal course. There is some evidence to show that the weakly contracting side of the bowl-shaped animal also aids in this tipping process. The margin flattens and is deflected upward as the portion of the rim that is pumping more strongly pushes down. The same routine is followed when the creature comes to rest after swimming. If it first touches the sand with its oral surface, it rises a short distance by normal swimming contractions. Then in a poised, mid-water position, it makes a 180 degree turnover—using the procedure of unequal contractions—and settles in its normal resting position.

In the aquarium and in the collecting pail many individuals were observed to hold themselves easily in position against the vertical side walls. Such a position is not possible on the flat bottom surface of the shallow lagoon, but could be of value if the animals found themselves over an irregular reef surface. In the collecting pail they readily attached themselves to the sides rather than be crowded on the bottom.

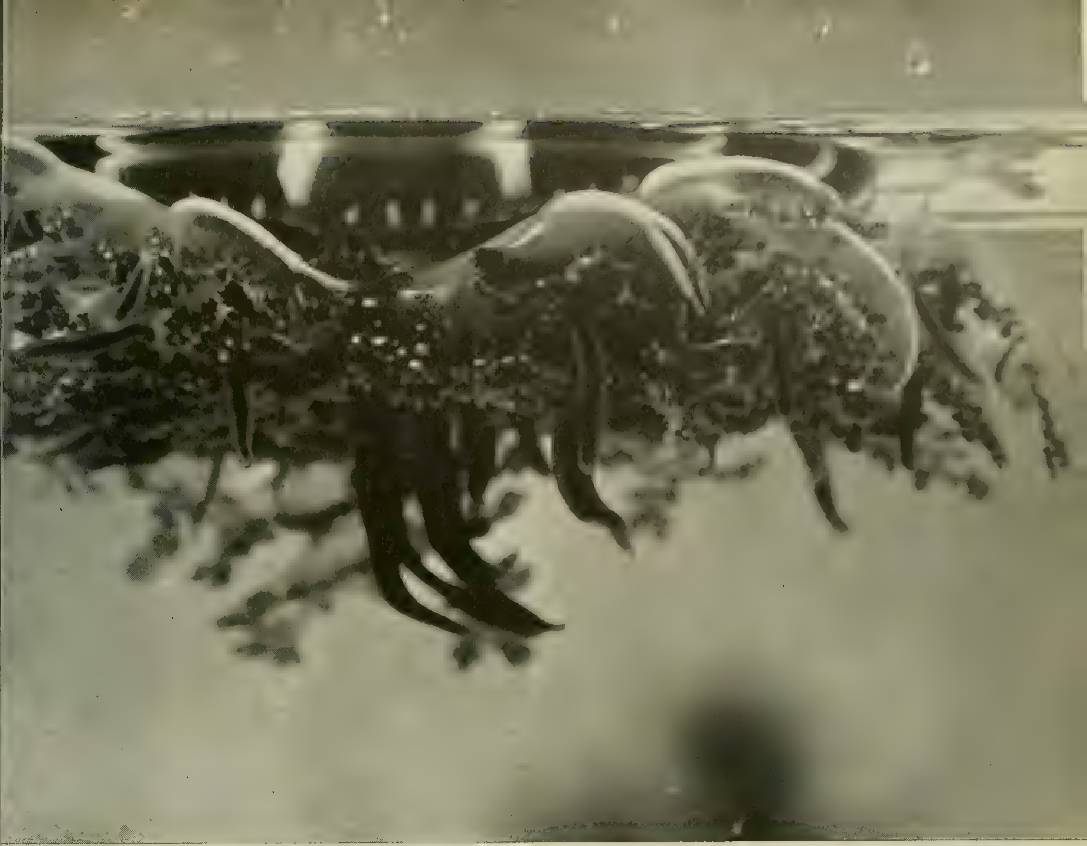
I considered these animals to be more active than any coelenterates of my previous experience, and was surprised to read in the literature that they are considered to be sluggish. Until I considered temperature as a factor, this seemed to be contradictory. My notes showed specific gravity readings for the water in which the collections and observations were made, and the temperature reading taken at that time—midday, July 29, 1964—was 35.5° C. The pulsations were at a rate of better than one per second. This high temperature and shallow water seemed to afford an optimum environment for the species, and may explain what appear to be conflicting opinions of the animal's behavior. Its normal swimming movements and its responses to disturbing stimuli were remarkably rapid and vigorous in comparison to what I had observed in northern waters, or what people had observed in animals kept in aquariums with temperatures as low as 23° C. It would seem that we have here a fine exposition of van't Hoff's law of the relation between temperature and the speed of a reaction. This law maintains that the speed of a chemical reaction is multiplied by a factor of from two to three times for every 10° C. rise in temperature surrounding the reaction. After considerable argument, this principle has been demonstrated to apply to cold-blooded animals.

Some of the jellyfish's responses to external stimuli are remarkable for an animal with no central nervous system. Poke a tiny hydra or a sea anemone with a non-injurious probe, and the whole creature contracts and remains motionless until trouble goes away. Annoy an ordinary jellyfish and it ignores you. Not so with *Cassiopeia.* Poke it, and it immediately responds with diverse and efficient muscular contractions that take it away from trouble. This reaction was most dramatically illustrated by the first group I photographed. After a session of picture taking they were carried to the nearby sea wall facing the open Atlantic and were carefully poured back into shallow water. This proved to be an unkindly act. Small waves coming in from the Straits of Florida created undertows that defeated all efforts the animals made to hold themselves in stable, normal positions on the sea bottom. Suddenly a most remarkable thing happened. At least three-quarters of them stopped trying to settle down, oriented themselves in unison and began to pump their way off, heading directly out to sea. I suppose they came to rest on the reef in the shallow water offshore, but when last seen they seemed to be heading for Cuba. (I was reminded of Xenophon's account of the "march of the ten thousand" as they fought their way back from Persia. Upon encountering a new threat they would hold a meeting, discuss the problem, vote on action to be taken, sing the war paean, and go back to battle.)

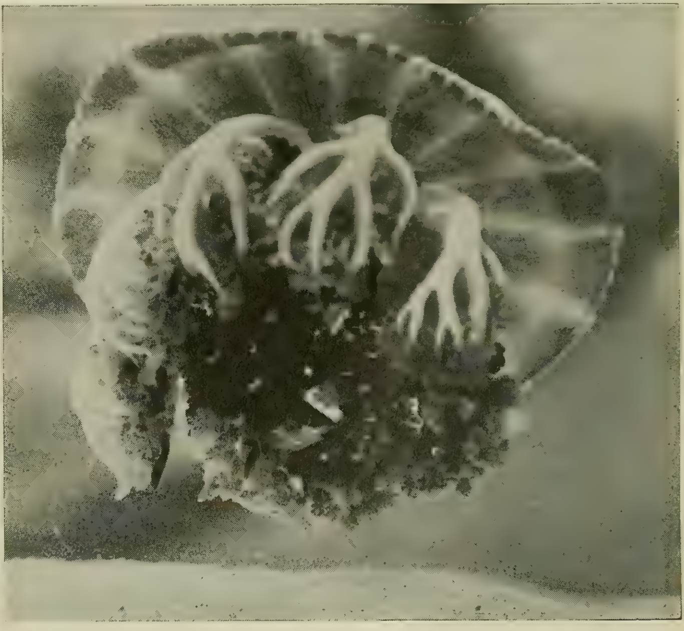
These harmless animals are pleasing to look at, and they are most diverting to watch. I commend them to your attention the next time you find yourself in the vicinity of a mangrove-bordered lagoon near Miami, in the Florida Keys, or in any other part of the Caribbean region.



Cassiopeia *continues its turn, below, one edge of bell still in contact with the sand. Animal rises from bottom, right,*



and all portions of rim begin to pump equally. At the water's surface, above, it assumes a typical jellyfish position.



# Channel Island Skunk

## Geological changes may have had influence on animal's speciation

By Richard G. Van Gelder

As laboratories for the study of evolution, islands have had a special appeal to biologists. The evolutionary theories of Darwin and Wallace were initiated by observation of insular animals and plants in the Galápagos and the East Indies, and in the past hundred years biologists have continued to take advantage of special study opportunities presented by island isolation. Is an island animal different from its relatives on the mainland? How different is it? How did it get to the island? How long has it been there? How much change has taken place since its arrival and isolation?

More often than not, the answers to these questions are not readily apparent. In fact, it is frustrating to have many of them remain unanswered, but it is also stimulating to speculate—to follow the hypotheses formulated from the "if" stage to the "therefore," and to see if the observations fit any hypothesis. If they do, the hypothesis becomes theory.

Skunks are strictly Western Hemisphere animals, and the three major types are found in various localities from northern Canada all the way to Patagonia. The spotted skunk (*Spilogale putorius*) is found from the southern border of Canada southward to Costa Rica, and from coast to coast except in the northeastern United States. A closely related species, the pygmy skunk (*S. pygmaea*), is found solely on the western coast of Mexico from Sinaloa to Oaxaca, and it measures only ten inches from tip of nose to tip of tail. The spotted skunk, with a range of some 3,500 miles from north to south and 2,500 miles from east to west on the mainland, is found off the California coast only on Santa Rosa and Santa Cruz, the two larger islands of the Santa Barbara group of the Channel Islands.

**Santa Cruz and Santa Rosa are the only islands inhabited by the spotted skunk. It has a wide range on mainland.**

The Channel Islands include Santa Catalina, the most famous, San Clemente, San Nicolas, and Santa Barbara, which form the southernmost, or Santa Catalina, group. To the north, about twenty-five miles south of the edge of Santa Barbara County, is another string of islands—Anacapa, Santa Rosa, Santa Cruz, and San Miguel—known as the Santa Barbara group.

There are three broad possibilities to account for the presence of spotted skunks on these islands. First, they could have swum to them or been carried to them accidentally on a log or a bit of floating debris; second, they could have been transported by man, recent or primitive; third, they could have walked at a time when the islands were connected to the mainland.

Let us examine these possibilities to see if any may be eliminated. Spotted skunks can swim, but it seems unlikely that they could manage to swim the ten to thirty miles of ocean that would have made it possible for them to reach the islands. Further, spotted skunks seem to have trouble crossing a water barrier of even a few hundred yards. For example, they have not crossed the Fraser River in British Columbia or the Potomac River drainage in Pennsylvania. The Mississippi River between Illinois and Iowa seems to work as an effective barrier, and it is only within the last few decades that they have managed to cross that river where it narrows farther north, between Minnesota and Wisconsin. Further, spotted skunks occur on the coasts of North America near other islands, but they do not live on any of them. In the more than 1,500 miles of coastline of Baja California, Mexico, there are islands close to shore and spotted skunks on the peninsula, yet these animals do not exist on the islands. Thus it would seem that the possibility of their swimming the many miles necessary to reach the Channel Islands is remote.

The second possibility is rafting. Could the skunks have been carried to the islands by accident on a pile of debris washed offshore and carried by ocean currents to the islands? This cannot be ruled out. If they arrived on the islands in this fortuitous manner, there is no way of determining when it occurred. Let us admit this manner of invasion is possible and continue with other hypotheses.

Could the Indians or even the early white settlers have brought these animals to the islands? It is possible but not too probable. To the best of knowledge, the Indians did not make pets of skunks, and even if they had done so, they would more likely have chosen the more docile, tractable striped skunk. The transporting of a non-descented skunk (and there are no data to indicate that the Indians knew how to remove the scent sacs) to the islands would scarcely have been a pleasant affair, and in general would have been an unlikely undertaking. There is also no evidence that the early white settlers deliberately moved skunks to the islands. Of course, the possibility exists that the animals accidentally stowed away on a boat, but this, again, is a very remote possibility.

There is yet another suggestion. Geologists tell us that early in the Pleistocene the Santa Barbara Channel Islands were connected with the mainland, because at that time the land was uplifted in that area. The fossil record shows that spotted skunks existed then, roughly one million years ago, and they could have walked to the place where the islands now are. Structurally, the islands are a part of the Santa Monica Mountains in Los Angeles County, and spotted skunks are still found on the mainland portion of the range. The subsequent geological changes that took place produced a water barrier that has separated the islands from the mainland ever since.

Although none of the other suggestions for the occupation of the islands that we have discussed can be eliminated completely from our thinking, the last one—that they walked across when the islands were connected with the mainland—requires the least effort on the part of the animals, and it, therefore, seems by far the most probable.

Assuming that the spotted skunks have been on the islands for nearly a million years, we might be able to discover something of how much they have evolved by comparing them with the spotted skunks that now live on the mainland. The island skunks differ notably from those on the adjacent mainland in two ways—the tail is shorter and the face is broader. To the taxonomist these slight differences are not sufficient to warrant the separation of the two at the species level. At present, the spotted skunks on the islands are regarded as a "weak" subspecies and bear the name *Spilogale putorius amphiala;* those on the adjacent mainland are *S. putorius phenax.*

A statistical analysis gives assurance that character differences between these two groups are real, not haphazard. The average size of any one character, such as length of tail or breadth of skull, will be different in any two samples, even if they are drawn from the same population, and in the present case the statistical techniques indicate that there is only one chance in a hundred that these measurable differences—the shorter tail and the broader face—are errors in the sampling. Even so, the differences are not great. For example, the average length of the tail in males of Santa Cruz Island skunks is 128 mm. In the Los Angeles County skunks, it is 158 mm.—less than an inch of difference. The facial breadth (measurement across the zygomatic arches of the skull) averages 38 mm. in the island skunks and 36 mm. in those from the mainland; the interorbital breadths are 16.5 and 15.7 mm., respectively.

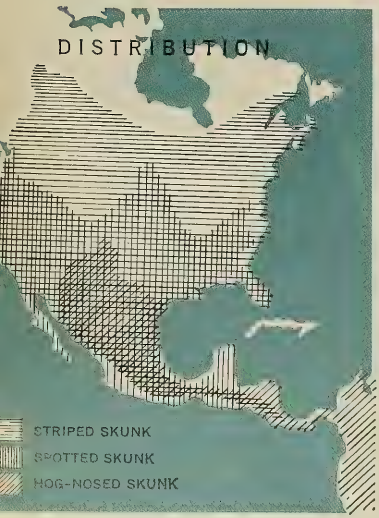
Even in color pattern the differences are slight. The underside of the tail of the insular spotted skunks is generally less than half-white—the average is 45 per cent; the underside of the tail in the mainland skunks averages 55 per cent half-white.

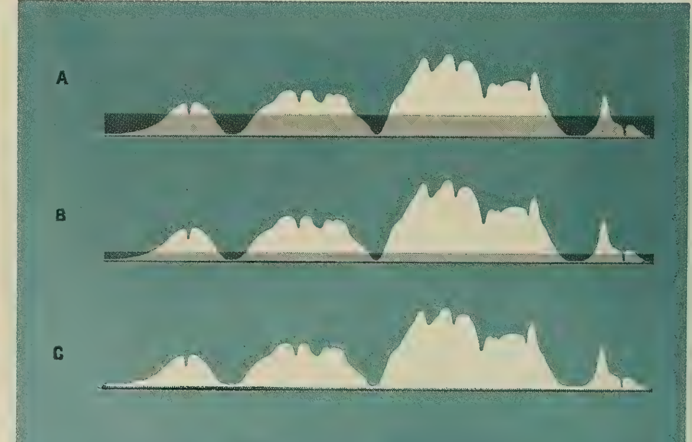
With the establishment of the differences between the mainland and island skunks, another question immediately comes to mind—how different are the skunks on Santa Rosa Island from those on Santa Cruz, and how long have they been separated? After separation from the mainland, the islands may have been connected with one another or may have separated, depending upon the fluctuations of the sea level and the geologic uplift of the area. If the water level were dropped 300 feet from its present level, all four of the islands would form a single unit, but they would still be separated from the mainland by more than ten miles of water. The depth of the Santa Barbara Channel between Santa Rosa and the mainland reaches 1,500 feet.

During the glacial periods, the withdrawal of ocean water to form the ice is believed to have lowered the sea level about 300 feet during the last (Wisconsin) glaciation. That would be the last time that the skunks on Santa Rosa and Santa Cruz Islands could have been in contact, and interbred. It is estimated that the rising water level at the end of the Wisconsin would have separated the skunks on the two islands about 8,000 years ago. The island skunks are more similar to each other than they are to those on the mainland, which fits the hypothesis that they walked over and then were separated—first from the mainland, and then from each other.

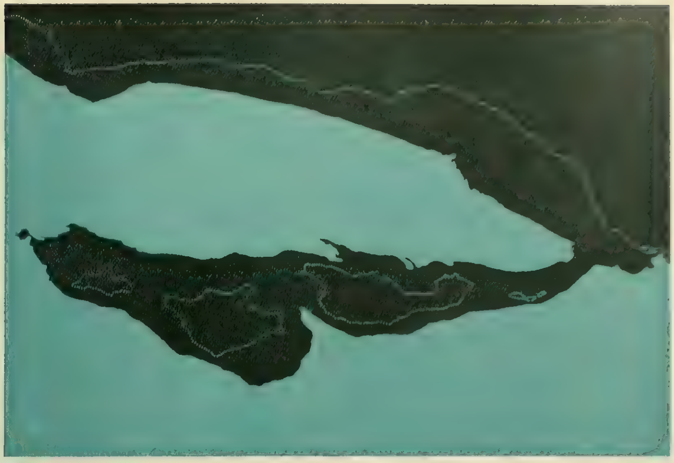
Careful comparisons of the skunks from the two islands reveal that there are differences between the populations, but these differences are not of the magnitude that would warrant their being placed even in different subspecies. One of the major differences is in total length, with those from Santa Cruz averaging 412 mm. and those on Santa Rosa averaging 426 mm.—about half an inch difference. All of the other differences between the two island populations are not consistent. For example, there is a significant difference in the height of the cranium between the males of the two islands, but not between the females; on the other hand, there is a significant difference between the females in length of head and body, a variant not true of the males.

To follow this thinking a little further, climate should be considered. After all, we have assumed that the skunks were on the islands during the last (and the previous) glacial periods. During the glacial periods of the Pleistocene, the climate on the Channel Islands probably was cool

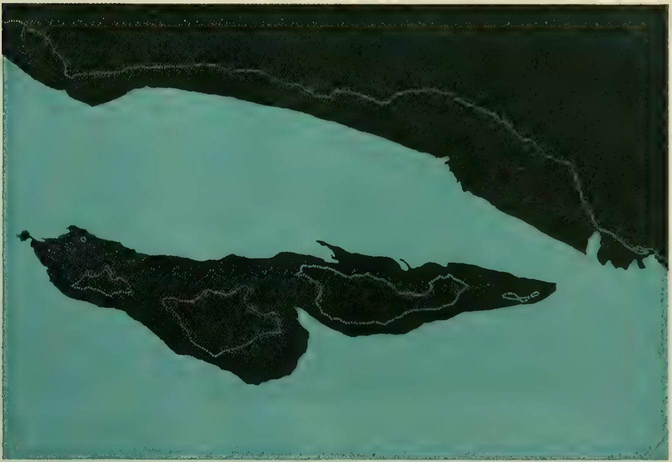




**Profile** shows three possible water levels—when sea was 300 feet above (A), where it is today (B), and 300 feet below contemporary level (C).

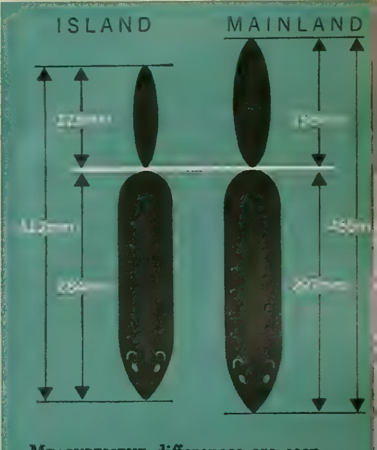


**Hypothetical view** shows the Santa Barbara group of islands connected to each other and to mainland, *above*, as they probably were in an earlier epoch.



**Three islands** remained connected to each other but were separated from coast by 10 miles of water. On modern maps islands appear approximately as below.

and moist, and in confirmation, evidence that Douglas fir—which thrives only in cool, moist areas—was present during this time has been found on Santa Cruz. After the last glaciation, the climate changed from cool and humid to the warm and arid condition that now obtains. It is therefore of interest to note that in its most distinctive characters (short tail, wide skull) the Channel Island spotted skunk resembles the subspecies (*S. putorius latifrons*) that is found in western Oregon and Washington, where the climate is still cool and moist. Such a resemblance could have occurred by chance, but it is also possible, and more likely, that it did not. For example, the Channel Islands could have been populated by animals with the characters of the Oregon–Washington skunks during a period of coolness and high humidity when *latifrons*-like skunks occurred (or had been forced down the coast by the severe climate) in the Santa Monica Mountains. When the climate became warmer, this mainland subspecies followed the cool, moist zone northward to its present location, while the Channel Island animals, being isolated, retained these characters or are still in the process of changing in response to the now-arid climate. There is also the possibility that the characters in which the Channel Island skunks resemble those of Oregon and Washington were evolved in response to the cool climate after the islands were separated from the mainland, and that they have either been



**Measurement** differences are seen in the island and mainland skunk.

retained or are still in the process of modification in response to the present warmth and aridity.

Differences in genetic composition provide the material for variation, and it is on such variation that evolution thrives. In a changing environment, those animals that have variations, however subtle, that give them a slight survival advantage over others will have a better chance to pass such attributes to their offspring. This is natural selection. The island skunks have been faced with a changing environment for the last 8,000 years. Unlike those on the mainland, they have not been able to escape it by moving, so they must adapt or die.

As a general rule, mammals respond to a warmer climate by increasing the size of their extremities. This is a mechanism by which an animal increases its surface area so that it may lose excess heat more rapidly. The length of the tail is one of the extremities that seems to respond to a warm climate by a size increase, and the idea that the Channel Island spotted skunks are in the process of modification receives some additional support from the study of tail length. In this character, the island spotted skunks show the highest degree of variation among some 2,000 specimens examined from all parts of the range. One would normally expect that the variation in such an inbred population as *amphiala* would be reduced, for there would be fewer genes for tail length in the population. With a smaller number of genes, the amount of variation would be limited. However, in length of the tail, the Channel Island skunks vary from 100 to 175 mm. (about 4 to 7 inches); the Washington–Oregon ones, from a much greater geographical area, vary only from 101 to 158 mm. (roughly a difference of 4 to 6 inches).

THE implication drawn from these data is that the spotted skunks on the islands were short-tailed during the cool periods of the last glaciation. Since then they have been evolving toward a longer tail—the normal response to a warm environment—but because they have not had the opportunity to come into equilibrium with the climate, they show great variability. The genes for short tails have not yet disappeared from the population.

Thus far, our hypothesis that the skunks walked to the Channel Islands seems acceptable, or at least the additional evidence available has done nothing to discredit it. There is, however, another bit of speculation. We have said that there are four islands in the Santa Barbara group, and that spotted skunks are found only on Santa Rosa and Santa Cruz. Why aren't they found on the other two islands, especially if, as we have said, the islands may at one time have formed a single unit separated by some miles of water from the mainland?

Anacapa is no problem. Actually, it is not a single island, but a string of several small islands extending for about five miles. The largest is less than a half mile wide and not quite two miles long; its elevation is 980 feet above the water level. By comparison, Santa Cruz is some twenty miles long and seven miles wide, and Santa Rosa is more than seventeen miles long and eleven miles wide. An individual spotted skunk will normally wander over an area of four square miles, so Anacapa is apparently just too small to support a skunk population.

Ordinarily San Miguel, the fourth island of the group, would seem to be an ideal place for skunks, because it does not differ much from Santa Rosa or Santa Cruz, except in size and conformation. San Miguel is about eight miles long and averages two miles in width, which should be sufficient to support a small skunk population. Its maximum elevation is, however, only 861 feet. During the fluctuations of water level and the uplift of land during the Pleistocene, there were times when large parts of the contemporary Channel Islands were below the surface of the water. This is indicated by the presence of sea shells of Pleistocene age high up on their slopes. If we raise the water level several hundred feet (or lower the islands—it doesn't matter which, in this case) the area of San Miguel available for inhabitation by spotted skunks would be greatly reduced; even at present its area is only 14,000 acres. Thus, during periods of submergence the spotted skunks might have been eliminated because the area was too small to support them, and they have not repopulated the island because they have been unable to cross the water barrier of 3½ miles separating San Miguel and Santa Rosa.

The theory to explain the presence of the animals on the Santa Barbara group, if correct, may lead to some conclusions on about how much evolution has taken place in spotted skunks. We may conclude that in one million years some slight but distinct differences have taken place between mainland and island skunks, and that these differences are sufficient to distinguish them on a weak subspecific level. During the 8,000 years that the two islands have been separated from each other, some differences have also developed between their respective skunk populations, but they are too slight to enable anyone to recognize

FOSSIL RECORD establishes that spotted skunks existed in Early Pleistocene, when they probably reached islands.

those on one island from those on the other with any degree of certainty. This would suggest that the rate of evolution in spotted skunks is not very rapid. Support for this contention also exists. In the Late Pliocene, some million years ago, there was a spotted skunk in Kansas: it is the oldest known spotted skunk, and yet it is almost identical with the pygmy skunk of today on the west coast of Mexico.

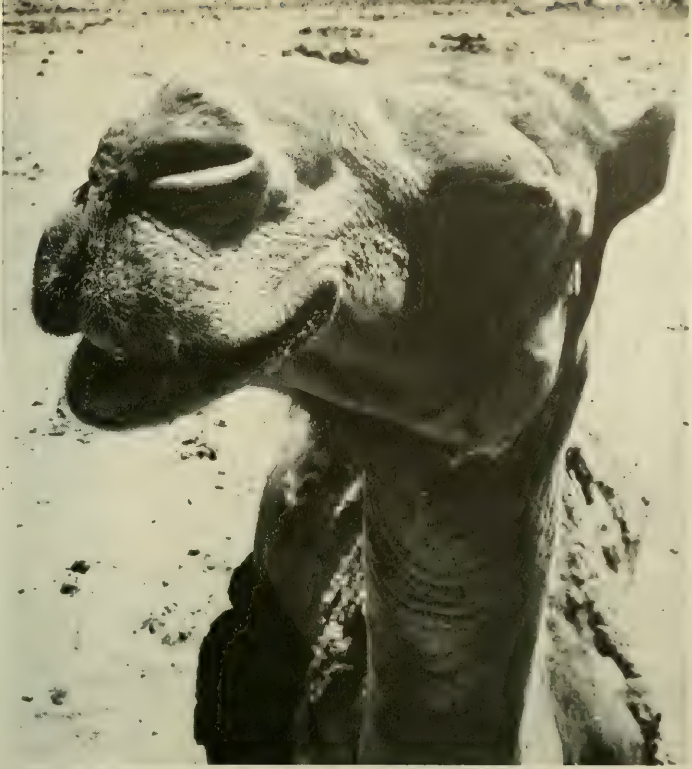
The reasons for this evolutionary rate are not known, but they are probably related to the skunks' unique defense, which enabled them to achieve a degree of stability in relation to the environments they faced during the Pleistocene. In addition, they are omnivorous, and thus are not especially affected by fluctuations in any specific kind of food. When vegetation is scarce they can feed on meat; when meat is in short supply they have insects, fruits, and berries for food. Thus they do not come into direct competition with many other kinds of animals and yet are adaptable enough in their food habits to take advantage of abundances. They can even store sizable amounts of food as body fat, which can carry them through a low food period or through weather so inclement that they cannot venture out to feed. It is probably through their adaptability and versatility that they have been able to survive with relatively little structural change over a period of many years.

The possibilities that the spotted skunks rafted to the islands or were carried by man cannot be discounted. In the absence of fossil skunks from the islands to establish their presence at an early date, a case can be made for each theory. The burden of evidence, however, fits the idea that they occupied the islands when there was a connection to the mainland; it is suited to the existing data, and does not require an accidental rafting or intentional or chance introduction by man.

# Desert Nomads' Economy Depends On Camel

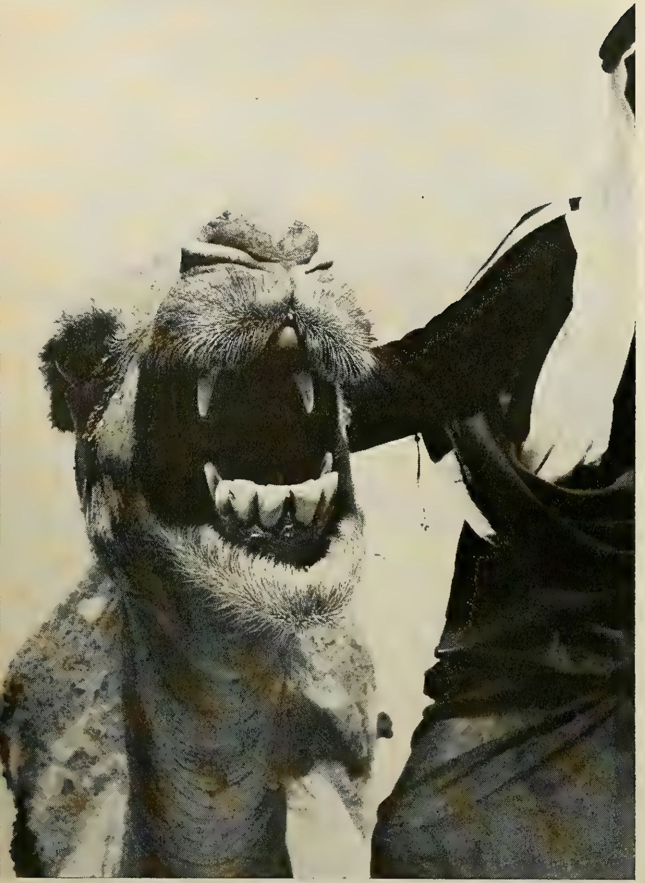
### Photographs by Niki Ekstrom

The ungainly, somewhat absurd-looking animals pictured on these pages dominate the lives of about one million people. For the bedouins who roam the Arabian deserts, *Camelus dromedarius* is the source of all food, shelter, clothing, and revenue, as well as the means of mobility upon which bedouin pastoral life is based. During a long, migratory trip across the desert to a village or an oasis, a camel, depending on its size, can carry a 350- to 550-pound load at the rate of thirty miles a day. While stories have exaggerated the animal's ability to retain water, a camel may be coaxed into drinking as much as sixty quarts, often a necessary precaution on a journey where there are few wells. In addition, camels thrive on plants rejected by other grazing animals. Camel milk may be the only food available to the bedouins for months; dung is used as fuel and in building. The animal is also the bedouins' sole marketable product; by breeding and selling camels, the bedouins can buy supplies for their nomadic existence.

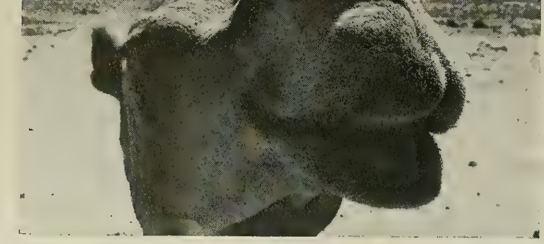


*Deep cleft in camel's upper lip is evident in picture at left. Groove allows camel's mouth to catch moisture from nostrils.*

*At a weekly market, below, the front legs of the camels that are for sale are tied together to prevent animals from bolting.*



*With powerful teeth, above, camel can eat bones and skin if necessary. The lower incisors are spatulate and somewhat slanted, while the canines are nearly erect.*



*The nostrils, seen in close-up at left, are slitlike in structure and can be closed to keep out sand and dust, an ability that serves the camel well during desert storms.*

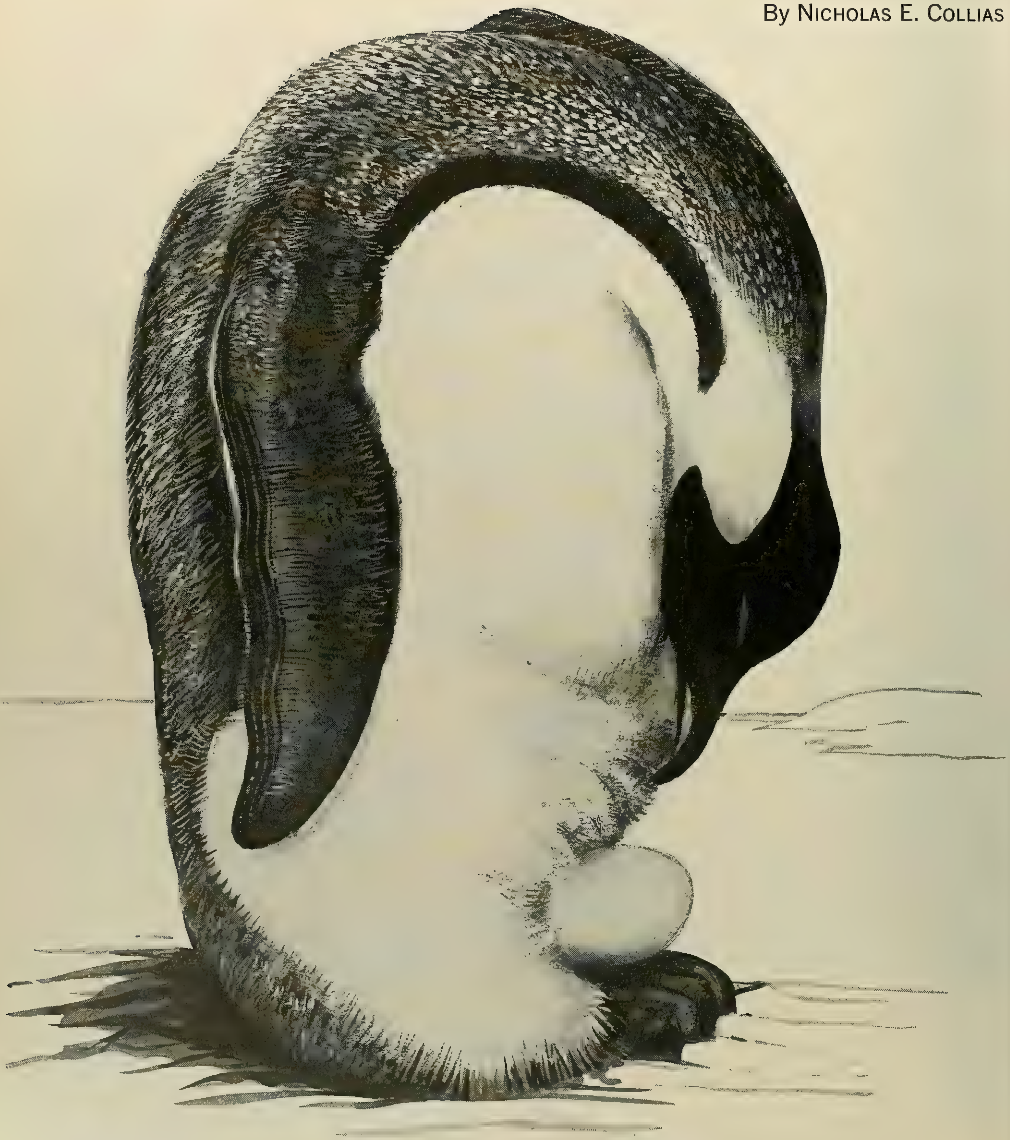
*Camels drink from a village trough at left. If well water is unavailable during a desert trek, they can drink brackish or even salt water with no apparent ill effects.*

*Children at right carry tin buckets in which to collect camel dung. The dung may be burned for cooking or warmth or mixed with earth to construct a shelter.*

# Evolution of

## External construction

By Nicholas E. Collias



*Emperor Penguin incubates one egg on feet, covering it with fold of skin.*

# Nest Building

## has been shaped by adaptive pressure

THE lives of birds usually center about the nest during the most active part of their existence. The importance of the study of nests was recognized by ornithologists of a past generation in the creation of a special term, "caliology" (from Greek *kalia*, hut or nest, + ology), for this area of scientific investigation. As a rule, however, nest collections of most museums compare very poorly indeed with the collections of bird skins to be found in the same institutions.

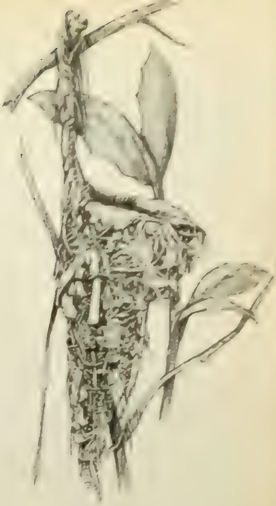
With the growing emphasis on the study of the living bird, there is a renewed emphasis both on the study of nests and on the behavior patterns associated with their construction and use. There is also an increasing recognition that nests and nest sites often bring to a focus the principal habitat requirements of a species. The extreme variations in nest form, structure, and elaborateness possess a significance that, to be understood, often requires close study of the bird and its nest under natural conditions. Furthermore, like other characteristics of species, the type of nest built depends on an evolutionary history to which we may gain some clue by means of comparative study of related species. A nest may be defined as an external structure that contains eggs and young and that aids in their survival and growth.

Building a nest often requires a great deal of time and energy in many species of birds. It is common for birds to make a thousand trips or more to gather and transport all the necessary materials. Natural selection may be expected to favor any behavior patterns that economize on undue effort, provided that some crucial advantage of the species is not thereby sacrificed. For example, theft of nest materials from other members of the species is very common among birds, but it is obvious that undue use of this method by all the individuals of a species could have a serious effect on the reproductive rate at the population level. For example, years ago Alexander Skutch estimated that up to half the nesting failures he observed in a population of Rieffer's Hummingbird (*Amazilia tzacatl*) in Central America resulted from stealing of nest materials from nests of other hummingbirds, resulting in the collapse of nests with eggs or nestlings. It is evident that the necessity to protect the nest itself has been an important force in the evolution of what is commonly called territorial behavior.

Competition between closely related species often results in the evolution of great differences in habitats and nest sites—differences that may give the birds their names. Compare, for instance, Barn, Cliff, Cave, Tree, and Bank Swallows, all well-known species in North America. In turn, differences in the nature of the substrate for the nest imposes special engineering requirements with regard to materials, form, structure, and placement of the nest for each species.

The primary and general functions of a bird's nest are to help insure warmth and safety for the developing eggs and young, but if the evolutionary forces involved in nest-building characteristics of any avian species are to be fully clarified, one must often be familiar with other aspects of its life history as well. Convergence in nest form and structure between unrelated species often furnishes significant clues to the nature of the ecological forces operating in the evolution of the characteristic nest.

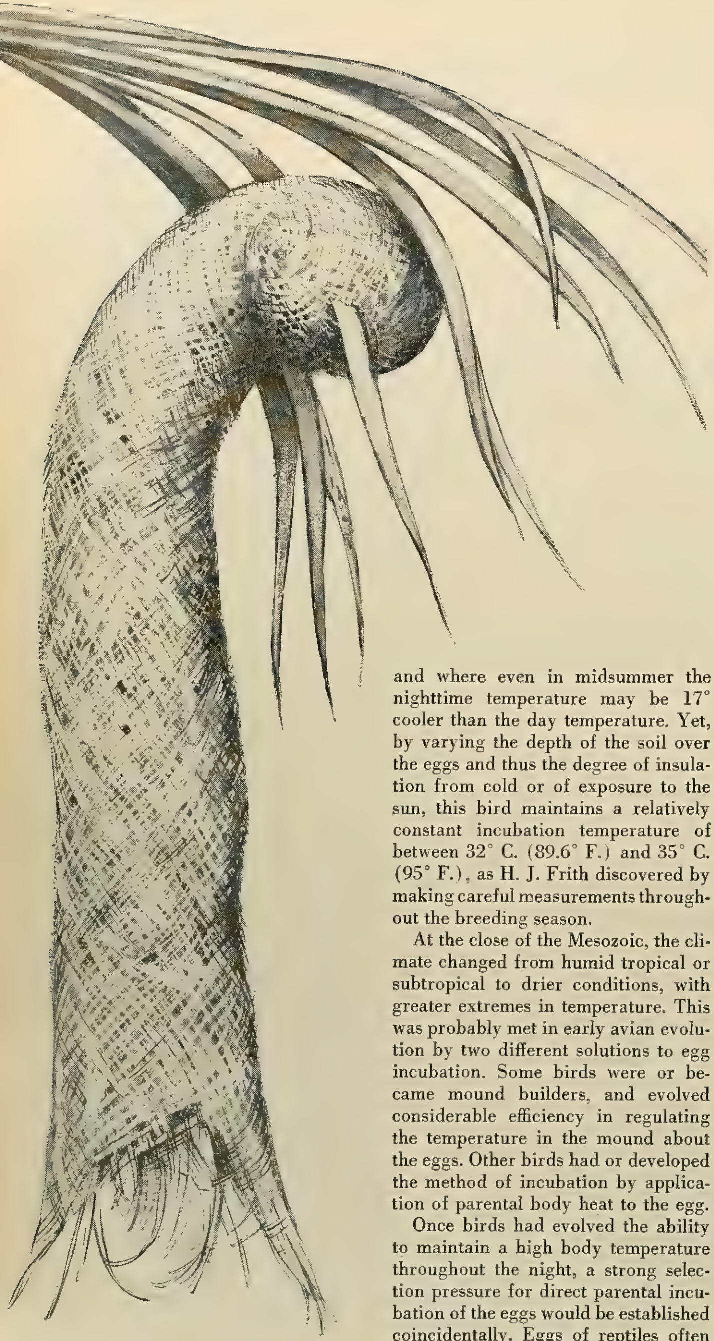
OUR main emphasis is not to use nest characters to help develop particular phylogenies in groups of related species, but rather to attempt to show how one can analyze the ecological nature of the selection pressures that have led to the evolution of the main types of nests. Of course, the problems of warmth and safety for the young are generally most acute for small birds and their young, which explains why, as a rule, birds of small body size build nests that are more elaborate and better concealed than are those of larger birds.


*Hummingbird nest is typical of well-insulated cup nest of very small birds.*

When birds evolved from reptiles they probably developed the ability to maintain a high, constant body temperature, more or less coincidental with the ability to fly. It seems likely that during the transitional evolutionary period, when flying ability and temperature regulatory mechanisms were being perfected, many birds became torpid during very cool nights. A few birds known today, such as the Poor-will (*Phalaenoptilus nuttallii*), become torpid during cold weather. The probable imperfection of body temperature control in ancestral birds is an argument in favor of the theory that the first birds did not incubate their eggs by sitting on them, as do most modern birds, but probably adopted some other means. Perhaps they buried their eggs in the soil and relied on heat furnished either by decaying vegetation or the sun. Many reptiles do this, as do birds of the family Megapodiidae. Within the confines of one genus, *Megapodius*, the nest may vary from a simple, small pit dug in the sand, large enough for just one egg, to gigantic mounds of soil and decaying vegetation from 30 to 60 feet long and reaching 15 feet in height—the largest bird nests known. Some of the megapodes have developed an efficient control over the temperature in their nest mounds far beyond that seen in any reptiles. One megapode, the Mallee Fowl (*Leipoa ocellata*), lives in arid regions of Australia where temperatures vary from below zero to above 38°C. (100.4° F.), period was shortened. The danger of predation from various nocturnal enemies, especially from the small contemporary mammals, would favor the habit of staying with the eggs and defending them, if necessary, during the night. F. H. Herrick has suggested that the origin of incubation by sitting on the eggs probably arose from the tendency of birds to conceal them as a protection from potential predators.

Use of natural or excavated cavities is common among birds and, in some instances, has evolved into quite elaborate excavations in the ground, in banks, or in trees. Almost half the orders of birds recognized by Ernst Mayr and Dean Amadon in their classification of the birds of the world contain some species that nest in cavities. Whole orders of cavity nesters are represented by the kiwis, parrots, trogons, coraciiform (kingfishers and their relatives), and piciform (woodpeckers and their relatives) birds. The habit of nesting in cavities furnishes considerable shelter and safety, particularly to small birds. Populations of House Wrens (*Troglodytes aëdon*), for instance, have often been increased by putting out a good supply of nest boxes. The shelter and safety of cavities has resulted in intense competition for these nesting sites. The House Wren discourages competition by other birds such as the Prothonotary Warbler (*Protonotaria citrea*) by puncturing the warbler's eggs. Along with each size class of woodpecker goes a host of other species that compete with the woodpeckers for the corresponding size of nest cavity. The European Starling is notorious in this regard. I have seen a starling in Ohio seize a Yellow-shafted Flicker by the tail and cast it out of the flicker's freshly dug tree hole in which a pair of starlings subsequently reared a brood. The German nature photographer Heinz Sielmann observed that when a European Nuthatch (*Sitta europaea*) takes over a tree cavity it forestalls its chief rivals, the starlings, by collecting mud from nearby puddles and plastering it around the entrance to the tree hole until the entrance is so small and narrow that, while the nuthatch can slip through, the starling cannot.

Different stages in the evolution of nest sites in tree holes are represented by different species. Some use natural cavities, others modify these cavities or excavate cavities in soft or



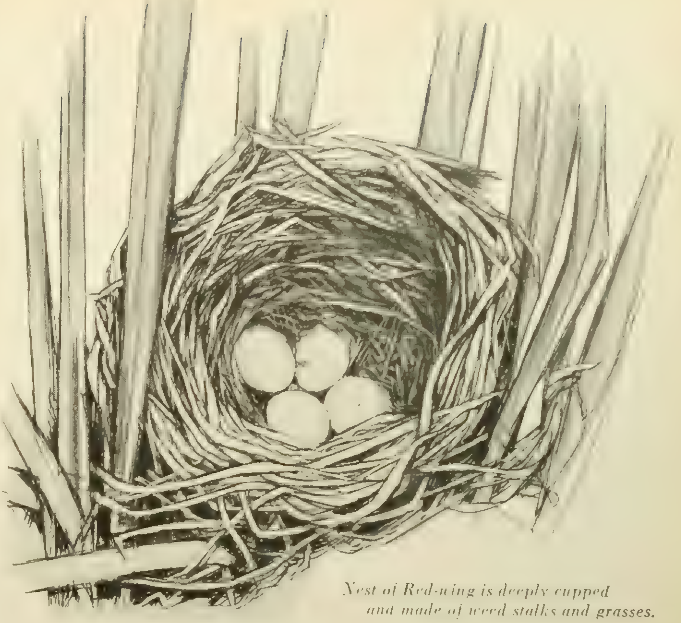
*Malimbe's nest is pendulous, woven skillfully with a long entrance tube.*

and where even in midsummer the nighttime temperature may be 17° cooler than the day temperature. Yet, by varying the depth of the soil over the eggs and thus the degree of insulation from cold or of exposure to the sun, this bird maintains a relatively constant incubation temperature of between 32° C. (89.6° F.) and 35° C. (95° F.), as H. J. Frith discovered by making careful measurements throughout the breeding season.

At the close of the Mesozoic, the climate changed from humid tropical or subtropical to drier conditions, with greater extremes in temperature. This was probably met in early avian evolution by two different solutions to egg incubation. Some birds were or became mound builders, and evolved considerable efficiency in regulating the temperature in the mound about the eggs. Other birds had or developed the method of incubation by application of parental body heat to the egg.

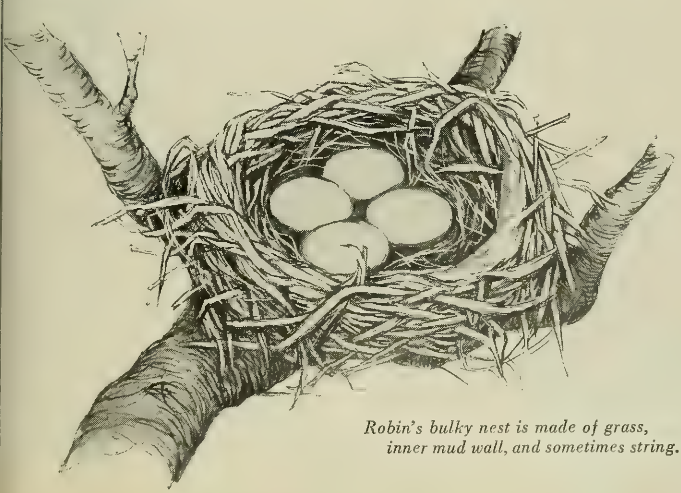
Once birds had evolved the ability to maintain a high body temperature throughout the night, a strong selection pressure for direct parental incubation of the eggs would be established coincidentally. Eggs of reptiles often take months to hatch, whereas those of birds frequently hatch within a matter of weeks. Total predation on the eggs would diminish as the developmental decaying wood or even in hard, living trees, as do some of the larger woodpeckers. Similarly, in the case of birds that nest in holes in the ground, various degrees of specialization are illustrated by different species. These range from a shallow scrape in many ground nesters, to a relatively short burrow like that of the Rough-winged Swallow (*Stelgidopteryx ruficollis*), to larger burrows such as those made by the related Bank Swallow (*Riparia riparia*), which may be six or more feet long, tunneled in something of an upward course and providing protection against driving rain.

THE evolutionary climax of excavated nests is the construction of nesting cavities by certain birds inside the nests of social insects. V. A. Hindwood has listed forty-nine species of birds, including kingfishers, parrots, trogons, puffbirds, jacamars, and a cotinga, that are known to breed in termite nests. In fact, some 25 per cent of the species of kingfishers of the world nest in termitaria. As the excavation by the bird progresses, the termites seal the exposed portions of their nest so there is no actual contact between birds and insects. Many birds that breed in termite nests do not normally eat the insects of the colony in which they are nesting. Birds that breed in nests of social insects are all from taxonomic groups characterized by nesting in cavities, and cavities in old and deserted termite nests are at times used by birds that normally breed in earth banks or tree holes, suggesting how the habit might have evolved.



*Nest of Red-wing is deeply cupped and made of weed stalks and grasses.*

Nesting in a hole goes a long way toward meeting the essential nest functions of warmth and safety, and thereby actually tends to block further evolution of truly elaborate increment nests built up from specific materials. In fact, nests built within cavities may undergo a regressive evolution. One can see all degrees of increasing simplification and reduction from an elaborate roofed nest to a mere pad, as in the case of the Old World Sparrows (Passerinae) that nest in tree holes.



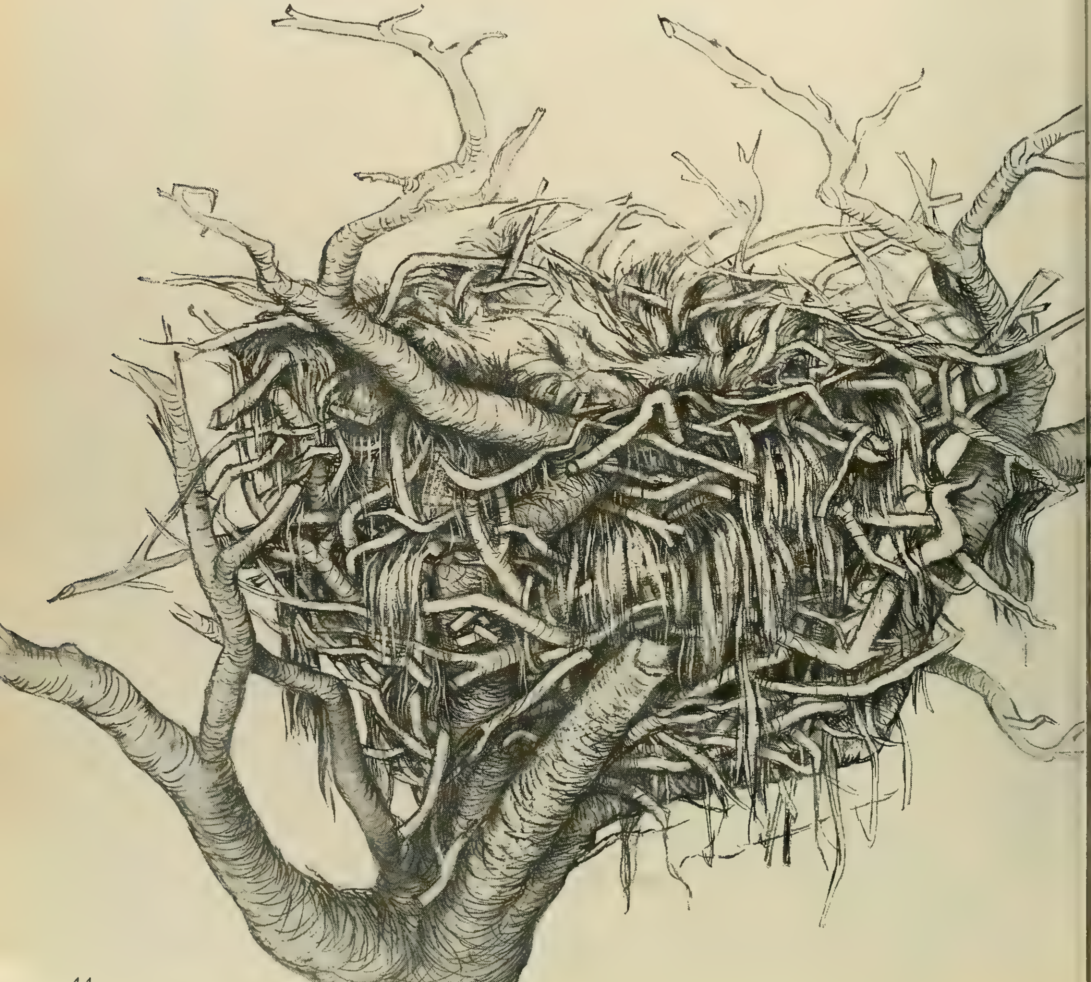
*Robin's bulky nest is made of grass, inner mud wall, and sometimes string.*

In contrast to cavity nesters, birds that build open nests on the ground are subject to a greater chance of nest failure. Consequently, there is a strong selection pressure to build an adequate nest, to develop other special means of parental care, or to evolve markedly efficient concealing coloration. Although with the origin of direct parental incubation it was no longer necessary to dig a pit for the eggs, most birds that nest on the surface of the ground today still begin their nest by making a circular scrape with the feet while crouching low and turning in different directions. This hollow may then be lined with various materials to protect the eggs from the cold, damp ground, while a rim of materials around the body of the sitting parent provides added insulation for the eggs. The materials are pushed to the periphery of this rim and built up into a circular form by much the same sort of movements of the feet and body as are involved in making the initial scrape in the ground. Many ground-nesting birds prevent the flattening down of the peripheral raised rim of the nest by repeatedly reaching out with the bill and drawing materials in to the breast or passing them back along one side of the body before dropping them. These patterns of making a nest can be seen, for example, in the Canada Goose.

Nests built on the surface of the ground are especially liable to be flooded. These nests are often built on slight elevations and, as in the case of the Canada Goose, may be built up higher during a flood. The Painted Snipe (*Rostratula benghalensis*) in Australia may lay its eggs on the bare ground when the earth is dry, but if it is covered with water, a solid nest of rushes and herbage is made. Similarly, the Adélie Penguin (*Pygoscelis adeliae*) builds up its nest of small stones if thaws cause flooding. In the Antarctic, where this penguin nests, William Sladen noticed one nest that had a stream of ice-cold water running through it. The male on the nest kept reaching forward, collecting and arranging stones about himself and his half-submerged eggs. By the next day the nest and eggs were above water, and eventually the eggs hatched.

Parental behavior may supplement or even substitute entirely for a nest under severe environmental conditions. In the Arctic, persistent close incubation by the parent bird is necessary and characteristic, regardless of whether or not the nest is well insulated. It has been found that the Semipalmated Sandpiper (*Ereunetes pusillus*), which builds no nest, keeps its eggs as warm as do other Arctic species that have substantial nests. The Emperor Penguin (*Aptenodytes forsteri*), which breeds in the Antarctic winter, has no nest, but rests its single egg on the feet, covers it with a fold o skin from the abdomen, and incubate it against the body. Probably no othe animal breeds under such trying conditions. At an opposite extreme, egg or nestlings exposed to strong tropica or subtropical sun in open situation are customarily shaded by the bod and wings of the parent, as in the cas of the Sooty Tern (*Sterna fuscata*) o Midway Island, whose nest is a mer scrape in the coral sand.

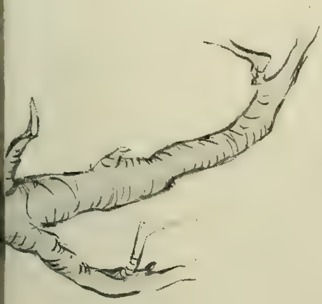
BIRDS nesting on the ground ar subject to high predation, and i is no accident that the classical cases o concealing coloration are found i birds, like the ptarmigan, which la their eggs in an open nest on th



ground. In certain cases, the color pattern of the eggs and the young, as in the European Stone Curlew (*Burhinus oedicnemus*), or of the young and the parent, as in the Whip-poor-will (*Antrostomus vociferus*), matches the surroundings so closely that the nest has disappeared in evolution, presumably because a nest itself would attract attention and be too conspicuous.

The dangers of ground nesting and the intense competition for tree holes have apparently provided a strong selection pressure for the evolution of increment nests placed on the branches of trees or, in some cases, against the faces of cliffs. Species of birds with precocial young (covered with down and able to move about) are generally ground nesters, whereas species with altricial (naked and helpless) young frequently nest on trees or bushes. In the prairie country of northwestern Oklahoma there are few trees, and R. L. Downing found that those Mourning Doves (*Zenaidura macroura*) that nested in trees were almost twice as successful in fledging young as were those that nested on the ground. There was a definite preference among the doves here for nesting in trees. In fact, Mrs. Margaret Nice, also in Oklahoma, found long ago that pairs of Mourning Doves nesting within forks of trees had a greater success than did those pairs nesting farther out on branches. Conversely, under safe nesting conditions, certain species of birds (such as the Osprey and Robin on Gardiner's Island, New York) that normally nest in trees may nest on the ground, thereby conserving the energy required to fly up into a tree with nest materials or with food for nestlings.

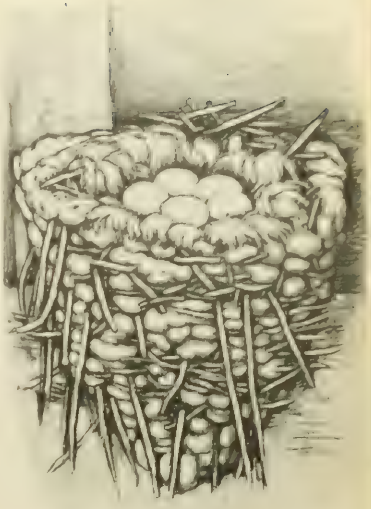
Drawings by
Walter F. Koenig



*Eagle's nest is large, roughly built, and lined with grass or pine needles.*

Tree nesting requires the solution of new types of engineering problems. The nature of the materials used varies with the body size of the bird and its lifting power. Large birds use large twigs and even branches, which will not readily be blown out of trees by the wind. Medium-sized birds use small twigs or grasses or both, sometimes adding mud to help attach and bind the materials. Many small birds use spider or insect silk as a binding material for the attachment of the nest to the substrate and to bind various other materials of the nest together.

The platform nests of large birds, such as the American Bald Eagle (*Haliaeetus leucocephalus*) and the European White Stork (*Ciconia ciconia*), may have twigs and branches added year after year and may become very large and very old. F. H. Herrick describes an eagle nest 12 feet tall and 8½ feet across, and estimates that it weighed over two tons when, in its thirty-sixth year, it fell during a storm, together with the tree. F. Haverschmidt has managed to date back to 1549 one White Stork nest that was still in use in 1930.



*Barn Swallow usually builds straw and mud nest on a rafter inside of barn.*

It seems probable that every type of material characteristic of the nest of a given species has a definite function, and that the proportions of different types of materials used vary not only with availablity but also with the requirements of particular substrate and habitat conditions. Otto Horváth observed that Robin nests in British Columbia contained more mud when the birds had to use short building materials, more tough and flexible rootlets when the nest was in an especially windy spot, and more moss when it was in a relatively cold microclimate.

Cup nests of very small birds are likely to be heavily insulated, as is true of the nests of most species of hummingbirds. There is some evidence that, compared with lowland species, hummingbirds that nest in high mountains build nests with relatively thick walls or seek the protection of caves.

Nests attached to the vertical faces of cliffs, caves, or buildings furnish protection against non-avian predators, but pose special problems for attachment of the nest. The swifts have generally used adhesive saliva, while the swallows have evolved toward more frequent use of mud, probably with some admixture of saliva. Different species of swiftlets (*Collocalia*) can be arranged in a graded series from such species as *Collocalia francica*, which make nests using pure saliva (the source of the ideal bird's-nest soup of the Chinese), through other species that use various admixtures of plant materials, to those that build nests of more conventional types. The nest cement of *Collocalia fuciphaga* is sparse and soft, and the nest, which is composed largely of moss and other plant materials, can only be placed on an irregularity in the cave wall that will take all or a good part of the weight of the nest. In contrast, nests of other cave swiftlets can be glued to vertical walls in the cave.

Building of a roofed increment nest is very rare among non-passerine birds, whereas almost half of eighty-two families and distinctive subfamilies of passerine birds recognized by Mayr and Amadon construct roofed nests or contain species that do so. Although roofed nests, aside from use of natural cavities, are unusual among passerine birds of the North Temperate Zone, they are typical of many tropical genera and families of passerines. In most instances, birds having non-pensile roofed nests first make a basal platform and then build up the sides and roof, and this sequence of building suggests that roofed nests probably evolved from nests that were at one time open above.

### A Classification of Nesting in Birds

I. Source of heat is the external environment. Eggs are generally buried in simple pit in the ground. Megapodes.

II. Source of heat for incubation is the body of parent.

1. Dig or use a nest cavity. Kiwis, parrots, trogons, coraciiform, and piciform birds.
2. Nest is open, not usually enclosed in a cavity.
    - a. No nests. Emperor Penguin, Nighthawk, Whip-poor-will.
    - b. Open nests. Most large birds and many small birds of the temperate zones that do not nest in holes.
    - c. Nests with roofs. Many small birds of the tropics, such as weaverbirds, sunbirds, flowerpeckers, wrens, Galápagos finches, and many tanagers and warblers of both the New and Old World.
    - d. Compound nests. Relatively rare in birds; examples include the Sociable Weaver of South Africa.

III. Brood parasites that make no nest but have their eggs incubated by some other species. Such parasites include many species of cowbirds, cuckoos, honeyguides, and the viduine finches of Africa.

Roofed nests may be made of very different materials by different birds—woven or thatched of grasses in many weaverbirds, of plant fibers in certain icterids, of short, heterogenous plant materials bound by spider silk in sunbirds and some titmice, and of mud in Cliff Swallows. The convergent evolution in such diverse instances is evidence of the great importance of a roof in the life of small nesting birds.

The roof of domed nests is important in shading young birds from the sun. Solar radiation is most intense in the tropics and would quickly kill small, naked altricial nestlings exposed to direct rays. The Galápagos Finches (Geospizinae), for instance, have an equatorial habitat and, unlike most Fringillidae, build roofed nests.

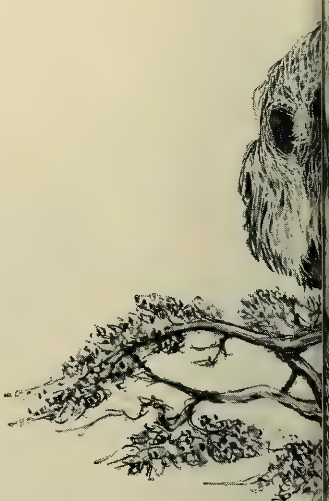
One function of the roof of domed nests must be to shed rain. Most small birds in the tropics nest during the rainy season when insect food is abundant. Skutch observed that the nests of the Yellow-rumped Cacique (*Cacicus cela*) in Central America are all open at the top during the early part of the breeding season before the rains. But as the rains begin, after the eggs have been laid, the top of the entrance is gradually roofed over and the nest entrance becomes a bent tube opening downward.

Protection from bird and mammal predators is aided by placement of nests in dense cover, especially in thorn trees. The buffalo weavers of Africa build a thorny cover or shell to the nest. Furthermore, the White-headed Buffalo Weaver (*Dinemellia*) is famous for placing thorny twigs along the boughs leading to its nest.

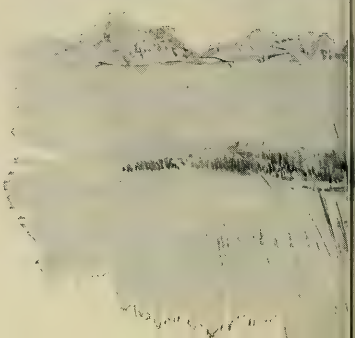
AMONG the predators of nestlings, snakes are more numerous and varied in the tropics than in colder localities, and perhaps roofed nests help deter snakes as well as other enemies. The weaverbirds all build domed nests, and, in addition, the nests placed in trees tend to evolve a firm pensile attachment and a bottom entrance with a long entrance tube, enhancing protection from snakes. In East Africa, Van Someren once watched a green tree-snake trying to get at the young in a Spectacled Weaver's nest. The snake negotiated the slender, pendent branch and reached the nest, but could not manage the twelve-inch tubular entrance and fell into the pond below.

A woven construction facilitates evolution of roofed and pendulous nests and enhances the nest's coherence. A whole series of representative stages can be traced in the weaverbirds from loose, crude, irregular weaving to the close, neat, and regular pattern to be found especially in those species that build pendulous nests with long entrance tubes. The nest of Cassin's Malimbe (*Malimbus cassini*), a black and red forest weaver of Central Africa, is perhaps the most skillfully constructed nest made by any bird.

In contrast to its importance among the social insects, a compound nest has been evolved by only a few species of birds. The compound nest consists of a common nest mass in which more than one pair of birds or more than one female of the same species occupy separate compartments. Such birds include the Palm Chat (*Dulus dominicus*) of Haiti, the Monk Parakeet (*Myiopsitta*



*Sociable Weaver nest is undoubtedly one of largest and most sophisticated.*

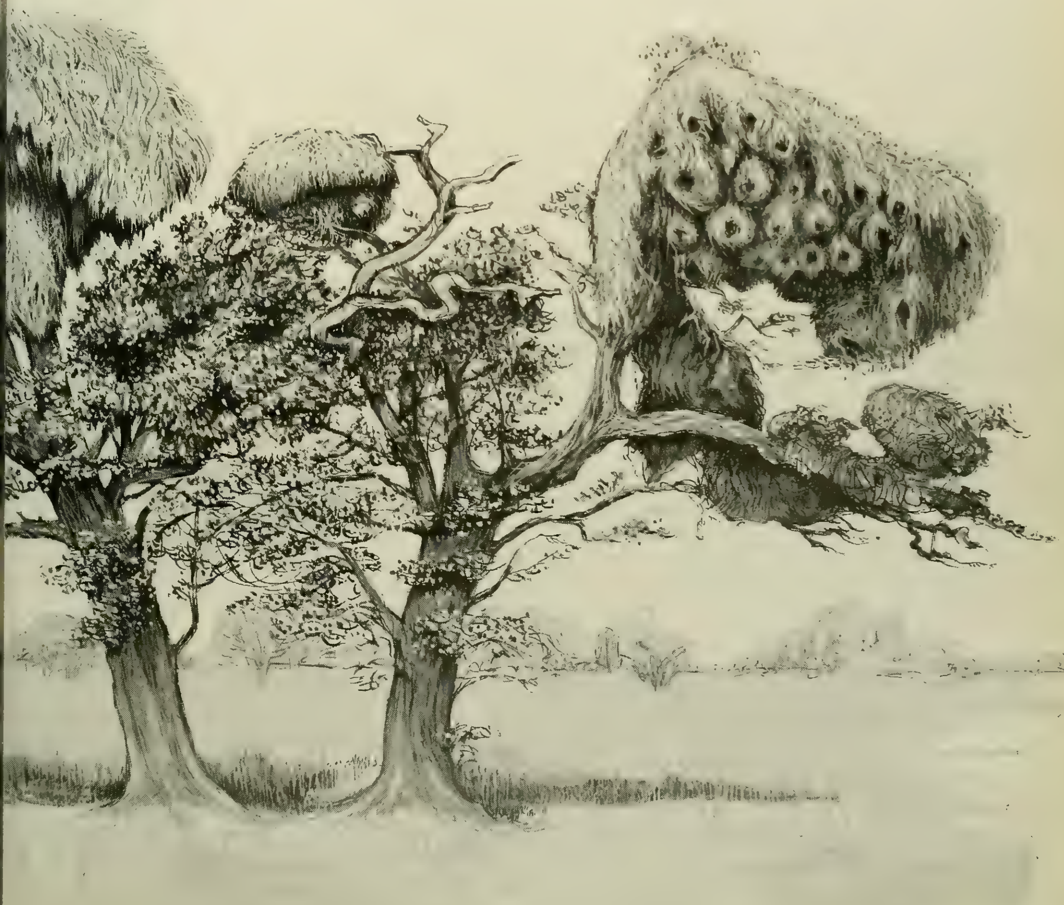


*monacha*) of Argentina, the Black Buffalo Weaver (*Bubalornis*) of Africa, and the Sociable Weaver (*Philetairus socius*) of the Kalahari Desert in South Africa.

The nest masses of the Sociable Weaver have often been compared to haystacks in a tree. These nests are not woven, but are thatched with dry grass stems. Each nest mass is often several feet thick, of irregular extent, and may be over fifteen feet long in the longest dimension. The top of each nest mass is dome-shaped, the underside relatively flat and riddled with scores of separate nest chambers. Many different individuals may work together on the common roof, which may be one key to the evolution of this remarkable structure. The roof enhances protection from predation for all, as does the outer thorny shell in nests of the Black Buffalo Weaver or the projecting eaves in those of the Monk Parakeet.

Special security from predation seems to be an important factor in making possible gregarious breeding, a phenomenon that is rather rare among small land birds, although common in sea birds on remote islets or inaccessible cliffs. One well-known example of gregarious nesting among passerine birds in an obviously safe nest site is that of the Cliff Swallows, whose mud nests are placed on the vertical face of a cliff or building. Colonies of the Sociable Weaver are frequently found, in camel's-thorn acacia trees, in which each of the many thorns may contain a colony of ants (NATURAL HISTORY, January, 1965). The habit of nesting in association with colonies of noxious insects is found in many African birds, and may have been a predisposing force in the evolution of the Sociable Weaver's compound nest. Possible intermediate stages are represented by the nests of a related species in East Africa, the Grey-headed Social Weaver (*Pseudonigrita arnaudi*). This gregarious species breeds in small colonies in which the different nests may be well separated, but when placed in ant-gall acacias, whose thorns give added security, many of the nests are grouped into common masses. We have counted up to nine nests in one mass.

When one considers the extent of variation in birds' nests there seems a vast difference between, say, the shallow scrape of a Sooty Tern in the coral sand of a tropical island and the immense communal dwellings of the little Sociable Weaver or the exquisitely woven cradle of Cassin's Malimbe. These variations are an exciting challenge to the ornithologist who would attempt to explain their origin in terms of the complex ecological and behavioral forces that have shaped the nests of birds in the course of evolution.



# SKY REPORTER

## Early 20th-century discoveries are keys to star evolution

By Thomas D. Nicholson

It is the usual practice at the American Museum-Hayden Planetarium to select a particularly interesting and popular lecture subject for the summer presentation, when large numbers of vacationers and tourists make up the audience. Last year our subject was "The Seven Wonders of the Universe," and their story was also told in a series of "Sky Reporter" articles that began with the August-September, 1964, issue of Natural History. One part of that fascinating story, "The Birth and Death of Stars," was chosen for expansion into the Planetarium summer presentation during July, August, and September, 1965, and for review in this column.

"The Birth and Death of Stars" is a story of modern astronomy and, as we now understand it, could not have been told a decade ago. It had to await discoveries made in the early twentieth century, a full appreciation of these discoveries, and an understanding of how they could be useful in describing the creation and evolution of a normal star. Modern astronomy also had to await findings in the field of physical science that explained the nature of matter and the mechanisms by which matter can produce energy.

An important milestone in our knowledge about the stars and how they evolve was the discovery that thermonuclear reactions taking place in the interiors of stars could account for all the energy manufactured and radiated by them throughout their obviously long lifetimes of millions or billions of years. By knowing how a star produces its energy, and knowing the chemical composition of stars and the clouds of gas from which they are born, astronomers were in a position to re-create in theory the physical conditions that might have existed at various stages in stellar formation and early life.

It has been established that space between the stars is filled with a tenuous gas, so rarefied as to be almost a perfect vacuum—but not quite. Here and there a presence of this interstellar gas is identified by its brightness, as in the cloud shown at the left, which is a portion of the glowing nebula in the constellation Monoceros. The light in these clouds may simply be reflected starlight, or it may be emitted by excited atoms that have absorbed energy from nearby hot stars. In other parts of space, the presence of invisible gas clouds has been revealed by the radio waves they radiate, or by their effects in dimming or reddening the light of distant stars seen through them.

The particles that make up this interstellar medium are in continual motion. Occasionally, we believe, the random motions of these clouds will bring together a sufficiently massive cloud of gas into a sufficiently small volume of space so that gravitational forces within the cloud will cause the cloud to collapse upon itself—slowly at first, then at an ever increasing rate. Such a cloud may initially be as large as ten million million miles across, or many times larger than our solar system. As the contracting process continues, the cloud grows more dense. Still dark, it may become so dense after it has shrunk to about twice the size of our system that it could appear as a small, dark spot against a cloud of bright gas behind it. In the photograph on the opposite page, careful study should reveal several small dark globules against the bright background. These may be collapsing clouds, already in the process of becoming stars; they might be called protostars.

**Rosette nebula** is in the constellation Monoceros, which is between Orion and Canis Minor. In it can be seen the small, dark globules that may be contracting protostars.

Deep inside these dark, still-contracting protostars, the density and pressure of the gas builds up under the weight of the surrounding cloud. With increasing pressure, the temperature also begins to rise, and the center of the cloud begins to glow. Some heat remains within the core of the protostar, but some radiates through the cloud, heating the gases until they begin to glow dull red. When the temperature reaches about ten million degrees in the center of the collapsing cloud, hydrogen atoms combine, forming helium, and releasing a new, rich source of energy that becomes available to the protostar.

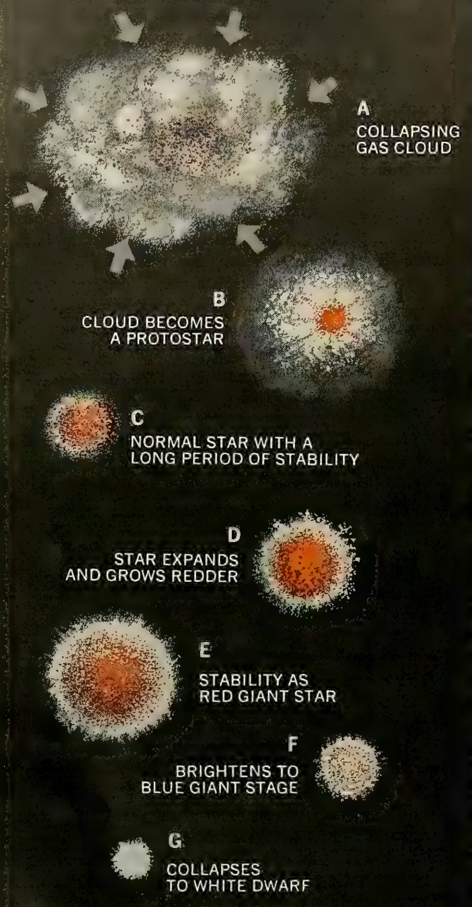
The energy generated through reactions at the center of the protostar slowly seeps through overlying layers of gas, heating them and enlarging the highly heated core where hydrogen fusion takes place. The vastly greater energy that now flows out through the cloud slows down the contraction of the gases and makes the surface hotter and brighter. Eventually, the nuclear energy supplied from the center becomes so great that it completely balances the contracting force. The size of the cloud and the core where nuclear reactions take place, the amount of energy produced in the core, and the temperature and brightness at the surface of the cloud all reach equilibrium. The protostar becomes a star, and begins a long, stable period as a normal star.

How long the stellar formation process may take and what kind of star will result depends principally on the amount of material in the original cloud. A cloud of approximately the sun's mass may take half a billion years to produce a star like the sun, and very massive clouds will form the brilliant, hot, blue stars of the universe, in perhaps one-tenth the time interval. Faint, red stars are produced from clouds having only one- or two-tenths of the sun's mass, and the process may take ten times as long as it takes to produce a sunlike star. The star will remain stable as long as its available hydrogen supply holds up, and that depends on how rapidly it is being used. The hydrogen fuel available for nuclear reactions in a star such as the sun may last as long as ten to fifteen billion years.

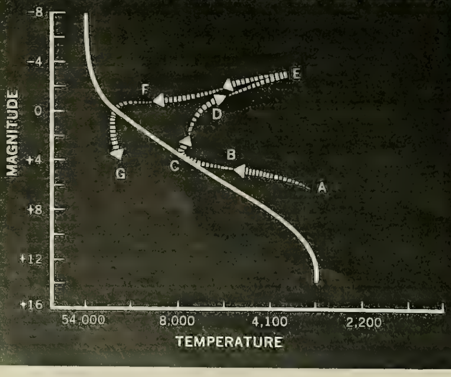
The supply of hydrogen available in the core of a star is enormous but not unlimited, and eventually it will all be used. As hydrogen begins to grow scarce, the amount of energy produced in the core gradually decreases, eventually becoming insufficient to balance the inward pressing

DR. NICHOLSON, the regular author of this column, is also Chairman of the AMERICAN MUSEUM-HAYDEN PLANETARIUM.

## EVOLUTION OF A STAR


A
COLLAPSING GAS CLOUD
B
CLOUD BECOMES A PROTOSTAR
C
NORMAL STAR WITH A LONG PERIOD OF STABILITY
D
STAR EXPANDS AND GROWS REDDER
E
STABILITY AS RED GIANT STAR
F
BRIGHTENS TO BLUE GIANT STAGE
G
COLLAPSES TO WHITE DWARF

Evolution of a sunlike star follows the broken line in diagram below. Other stars evolve on parallel tracks and spend long, stable periods along solid line; here most stars that are visible to us today are observed.



force of gravity. The star's core, now rich in helium, wil begin to contract once more and, as it contracts, the temperature in the core gases will begin rising. Some of thi energy will go out to the layers of gas surrounding th core, where hydrogen may still be abundant. Hydroge fusion will then begin in shells of gas surrounding the collapsing core. When this process begins, more energ reaches the surface of the star than ever before, and tha surface begins to change rapidly. The gases become hotte and expand. Then the expanding gases cool and the effective optical surface of the star grows larger, cooler, an fainter, although the star itself becomes brighter (owin to the fainter light coming from a much larger surfac area). The star very rapidly, perhaps in only a few millio years, changes into a red giant star.

UP to this transition stage in the evolution of a sta similar to the sun, the picture is fairly clear. Beyon this, however, the life history of a star is not at all clear Nevertheless, we can make some fairly good guesses concerning what may happen next and why.

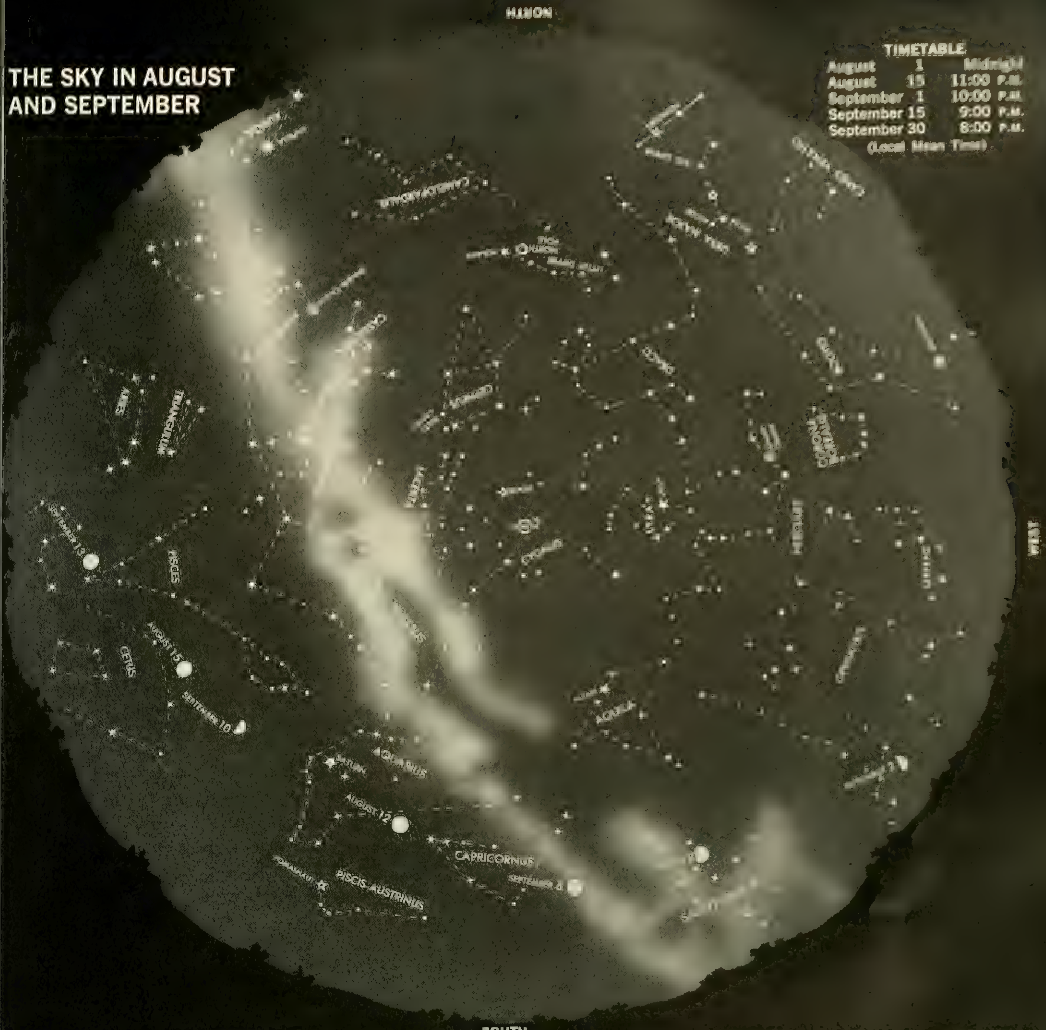
After the transition stage, it is possible that the star wil again settle down to a period of stability as a red giant sta a stage that may last for several hundred million years Eventually, the temperature in the contracting core will become high enough to produce a second nuclear reaction– the fusion of helium into heavier chemical elements. Thi reaction will again supply the energy to stop the contracting process and to maintain the size and energy output of th star in equilibrium for another period of time. However, w believe that the helium reaction takes place at a rapid rate so that this second period of stability in the star's life i much shorter than the first.

When the helium supply in its core is exhausted, the sta must change again. Just how it changes is not known, bu we believe that it may rapidly grow smaller, hotter, and brighter. It does not seem possible that a new, stable sourc of energy will be available, so the core, and eventually th entire star, will enter into a stage of final collapse. Afte passing through a "blue giant" stage, the star may become "white dwarf." Continual contraction eventually shoul squeeze all of its material into an object not much large than the earth. Internal pressure and temperature become extremely high, and the star's surface glows brilliantly. The star has, by then, become so small that it is actually seen a a very dim object.

Eventually, when no further energy is available, the sta should cool slowly, until it finally ends as a cold, dark dense black dwarf—a burned-out star. By this time its material would be so dense that a teaspoonful could weigh more than a ton on the earth.

Thus far, the picture we have drawn of the birth, evolution, and death of a star has been based on theoretical considerations alone. We can see in the sky certain objects tha may be protostars in an early stage of formation, and w have observed white dwarf stars, which we believe may b stars in their final stage. But is there any observational evidence to support the evolutionary picture we have drawn There is, and it seems to fit the theory. Next month, i "Sky Reporter," we shall review the accumulated evidence

# THE SKY IN AUGUST AND SEPTEMBER



**TIMETABLE**

| | | |
|---|---|---|
| August | 1 | Midnight |
| August | 15 | 11:00 P.M. |
| September | 1 | 10:00 P.M. |
| September | 15 | 9:00 P.M. |
| September | 30 | 8:00 P.M. |

(Local Mean Time)

| | |
|---|---|
| First Quarter | August 4, 12:47 A.M., EST |
| Full Moon | August 12, 3:22 A.M., EST |
| Last Quarter | August 19, 10:50 P.M., EST |
| New Moon | August 26, 1:50 P.M., EST |

| | |
|---|---|
| First Quarter | September 2, 2:27 P.M., EST |
| Full Moon | September 10, 6:32 P.M., EST |
| Last Quarter | September 18, 6:58 A.M., EST |
| New Moon | September 24, 10:18 P.M., EST |

August 1-2: Mars (magnitude +1.2), located in Virgo, appears near the crescent moon on these nights, to the left (east) of the moon on the evening of the 1st, to the right (west) of the moon on the 2nd.

August 13-14: Saturn (magnitude +0.9) is in conjunction with the moon at about sunrise on the 14th. Saturn, in Aquarius, will be visible nearly all night in August and September, moving from east at dusk to west at dawn.

August 15: Mercury, at inferior conjunction, moves into the morning sky.

August 22: Jupiter and the waning crescent moon are in conjunction at 2:00 A.M., EST, when both will appear together. Jupiter (magnitude about —1.8) is a bright morning star in the eastern or southern sky throughout August and September, moving slowly from Taurus into Gemini.

August 28: Venus is the brilliant evening star to the left of the crescent moon in tonight's sky. Visible for more than two hours after sunset, it will brighten and appear higher in the sky each evening until December.

August 30: Mars will appear close to the crescent moon in the sky tonight, the second time this occurs this month.

September 1: Mercury is at greatest westerly elongation. It rises in the eastern sky, and may be seen as a morning star for a few days before and after the 1st.

September 5: The bright star near Venus in the eastern sky on these evenings is Spica. Venus (magnitude —3.5) moves to the left and above Spica (magnitude —0.9) from the 5th to the 8th.

September 6: At opposition at 11:00 A.M., EST, Saturn is nearest the earth, at a distance of 805,400,000 miles.

September 10: The full moon tonight is the harvest moon. It appears to rise at nearly the same hour from the 9th to the 12th (actually it is retarded by about 25 minutes from night to night).

September 23: The sun arrives at the autumnal equinox at 1:06 A.M., EST; autumn begins in the Northern Hemisphere.

September 27: Mercury, at superior conjunction, passes on the far side of the sun and enters the evening sky.

September 28: Mars, in the eastern sky until two hours past sunset, is in conjunction with the moon at 8:00 P.M., EST.

**Often**, alpine buttercups, *Ranunculus adoneus*, bloom through snow, *above*, that falls on the plant-rich tundra in Rocky Mountain National Park.

# Floras

## Treeless ecosystem

By Paul D. Kilburn

Isolated mountaintops begin to turn light green in midsummer above the deep green of the spruce-fir subalpine forest in the Colorado Rockies. This pale green represents a unique form of vegetation composed of plants that can withstand the climatic rigors of mountaintops, which trees cannot.

# of the Tundra

## is subject of intensive study in Colorado

Here, on shallow rock soils in a short growing season, with the air temperature never above sixty degrees and temperatures near freezing at night, occurs one of the strangest vegetation types in the world, the alpine tundra.

Our word "tundra," adopted from the Russian, is itself from the Finnish word *tunturi*, which means, literally, "marshy plain." It is used to describe the vast expanses of treeless vegetation that border the Arctic Ocean throughout Eurasia.

The alpine tundra, although better drained and far less extensive, is strikingly similar to the tundra of Eurasia and North America. It contains many of the same plant species, and by virtue of its proximity and ready accessibility it promises to be more frequently visited and studied by layman and botanist as interest in this biota increases.

The tundra of the Colorado Rockies is perhaps the most extensive and accessible in continental United States. The largest expanse occurs above 11,000 feet in Rocky Mountain National Park, where Trail Ridge Road traverses some eight miles of ungrazed and unspoiled tundra vegetation. This highway, although closed in winter, makes possible the study of the tundra throughout the growing season. About two million people per year visit the Park, and over three-quarters of them go up on Trail Ridge to trample and hike (and shiver) in this vegetation during the summer. Twenty-five miles to the south, on smaller but similar Niwot Ridge, is the mountain field station of the University of Colorado. Here, considerable research is centered on the patterns, processes, and climates of this tundra ecosystem.

The persistence, indeed thriving, of plants under severe Arctic-alpine conditions has long interested botanists, and study and research in both Arctic and alpine tundra have been pursued for many years. Discovery of many unusual and unsuspected cold climate problems in Alaska during World War II gave impetus to, and eventually produced funds for, much basic soil-vegetation research in this region during the postwar decade. In recent years fundamental studies by plant ecologists from Duke, Illinois, and Colorado Universities have considerably enlarged our information about the persistence of this vegetation. For instance, scientists consider the alpine climate to be more severe than that of the Arctic by virtue of its stronger winds, different day length patterns, far greater daily temperature fluctuations, more intense ultraviolet radiation, and higher surface soil temperatures. The effect of each of these features on vegetation and plant adaptations is now the subject of considerable ecological attention.

TUNDRA first appears in openings in the Engelmann spruce-subalpine fir forests that grow above elevations of 10,000 feet. These forests, which are dense at lower altitudes, gradually become more open as one climbs higher until, usually above 11,000 feet, the trees become the dwarfed residents that make up the *Krummholz*, or tree limit. In the upper reaches of this forest the trees become shrubs only two or three feet tall, with trunks almost parallel to the ground. Here is tree limit, and the low-growing trees resemble islands in the sea of tundra. Despite the sharp contrast between forest and tundra, many species are common to both, and the transition between the two is a gradual continuum.

The reason for tundra existence at high elevations is still not well known. Soil differences cannot explain the occurrence of forest at lower elevations and tundra above, for the same bedrock and soil parent materials are common to both; neither can precipitation, which is often identical, nor can coldness alone. Twelve years of weekly weather records at the University of Colorado field station indicate it is not as cold in the tundra as in the subalpine regions. The major climatic factor distinguishing the two ecosystems in Colorado is wind velocity, for the higher tundra areas lie at the mercy of the intense winds all year. The wind is inimical to tree establishment in high and exposed reaches of the mountains, as is readily apparent near tree limit, where branches that project above hill, rock, or plant protection, are quickly shorn of needles and life. Woe to the tree in the open!

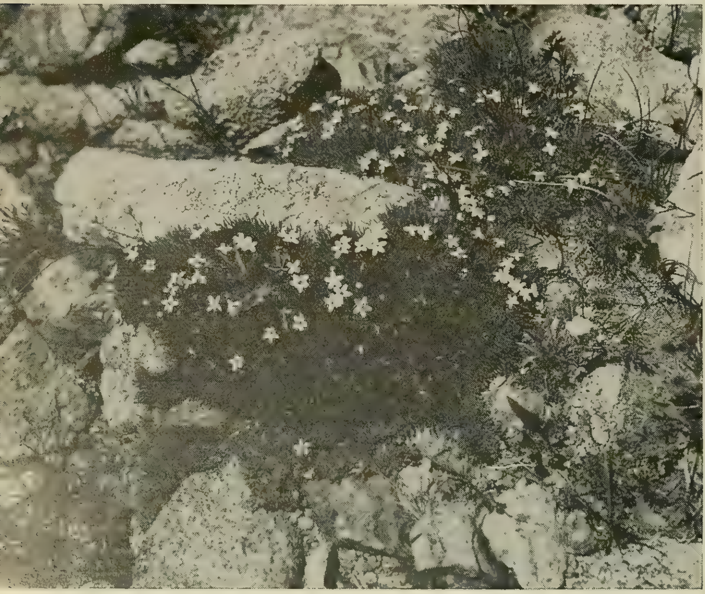
The topography of large areas of the alpine tundra is surprisingly gentle in the easternmost outer range of the Colorado Rockies, the Front Range. The accepted picture of tundra consisting of scattered plants in rocky and shallow soil of high mountains is borne out in the areas of steep relief, but in many areas the ridges and mountain sides above tree limit are gently rolling. The main study area at the Colorado field station is a gently rolling plateau some four miles long and about one mile wide. Here the tundra reaches maximum development. In places the soil is more than a foot deep, rich and black, and the vegetation, although low, is almost lush. Such stands provide ecologists with a base point with which to compare less dense tundra of other areas.

It is the forms of Colorado tundra plants that are so striking at a first visit, for many are quite unlike more common forest or grassland herbs and shrubs. One can see large-flowered daisies, cushion clovers, phloxes, small grasses, and creeping willows, none of which reaches more than two or three inches above the ground. They are true "belly plants"—plant physiologist Fritz Went's term to describe the tiny desert annuals that force one to get on the ground to view them fully. Most tundra plants are less than six inches tall, while some with giant flower stalks rise over a foot above the ground. The wind is far less severe in the summer, allowing these large-sized flower stalks to reach maturity unless they are destroyed by the not infrequent hailstorms.

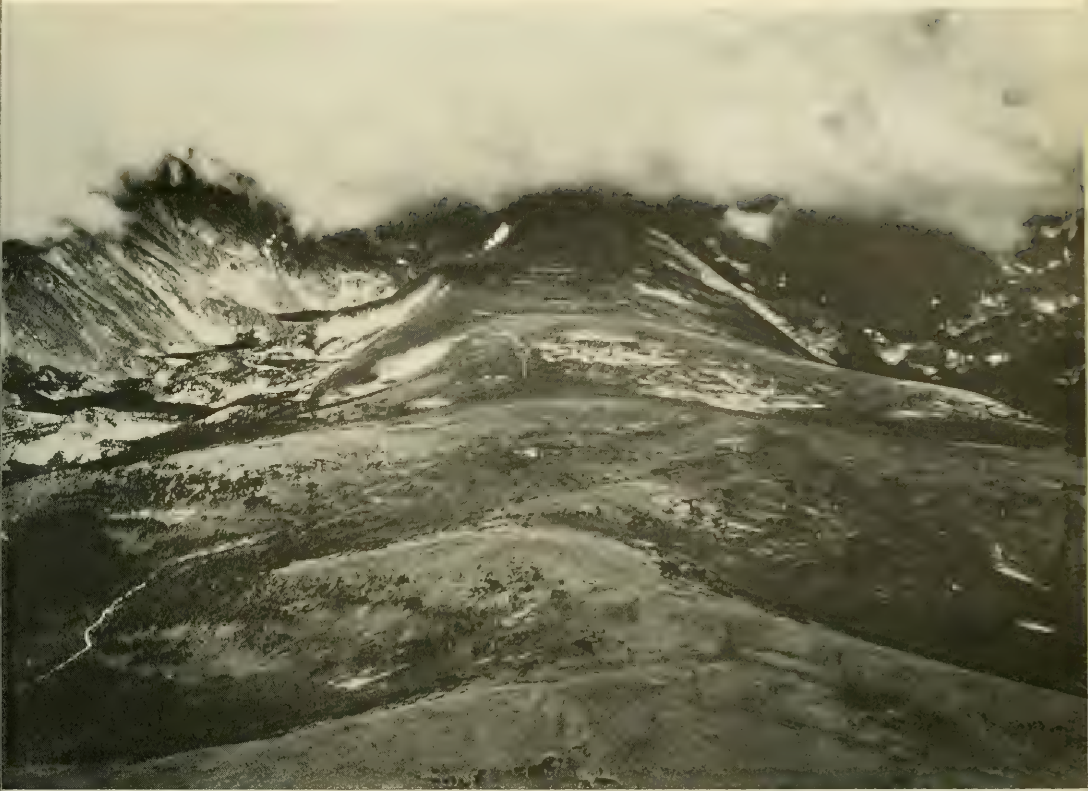
Despite their small size, these plants are all perennials. The only annual of the Colorado tundra is a rarity, the tiny *Koenigia islandica,* which measures two inches from root tip to flower. It is found only in exposed, moist frost boils (patches of bare soil in moist depressions, kept bare by freezing-thawing action) where earth churning quickly breaks perennial root systems and kills the plants. In these barren, primary succession areas *Koenigia* lives its somewhat solitary existence, the one exception to the "no tundra annuals" rule, but making an almost non-existent contribution to tundra biomass.

Why annuals, which are so abundant in the severe habitat of the deserts, should be virtually absent in the tundra is not clear. There are few good arguments and no experimenta-

**Moss-campion,** ***Silene acaulis,*** **can be found between lichen-covered rocks; cushions may be a foot across and some centuries old. Its range is circumpolar.**



**Repent willow,** ***Salix reticulata,*** **is but two inches high. Stems hug ground.**



Niwot Ridge, *above*, here faces west to cloud-shrouded Continental Divide.

Marsh-marigold, *Caltha leptosepala*, sends up white blooms from meltwater, *below*. Related to eastern yellow form, it is most abundant at low elevations.

tion to show why annuals have not adapted to tundra life. Certainly there is enough bare soil, and the six-week growing season equals that needed by many desert annuals. Do the cool temperatures, coupled with the short growing season, so restrict photosynthesis and growth that competition with perennials has eliminated all annuals that may have evolved? The problem needs study.

Because of the severe climate, natural selection has favored plants that lie close to the ground. The cushion plants are magnificent examples, even though their perennating buds (where the new spring growth emerges) are above the ground surface, and are not protected like grasses, whose buds are usually just at the surface, nor like bulbous plants, whose perennating parts lie protected under several inches of soil during the winter. The cushion mats, resembling flat pincushions or green plates turned upside down, rise only an inch or so above ground level, although they may be over a foot across. They are most abundant in the more exposed parts of the tundra. They can "take it" as no other plants, and may live more than a hundred years. They flower profusely in midsummer, and a moss-campion cushion may produce up to one hundred flowers.

We are indebted for perennating bud classification to C. Raunkiaer, a Danish plant ecologist of the twenties who made several other important contributions in quantifying plants and vegetation. He showed that in tropical rain forests most species are trees with buds fully exposed to the environment, and that this is not disadvantageous because the climate is so uniform. In deciduous forests with far fewer tree species the majority of the plants consist of herbs and grass-like plants with buds at or below the ground level, and hence much better protected. In the desert the majority of species are annuals, with no perennating buds on the plant at all. Instead, efficient protection is furnished by a dormant seed. Raunkiaer summarizes the percentages of each life form in each major type of vegetation. A comparison of these percentages allows one to rate the severity of the climate in each vegetation type. The bud position of most tundra plants—just above ground—gives them considerable protection, and thus corroborates what we know of the tundra climate.

While cushion plants are perhaps the most unusual and conspicuous elements in the tundra, there are other unusual adaptations. One is the repent form of certain tree genera. Tiny willow trees creep over the ground, forming patches some three to five feet across. There is no single main stem, and the diffuse growth sends its flowering spikes up to a maximum of three inches. Without the fruiting structure one would be hard put to decide that this was even a willow.

Another unusual habitat for a different form of life is provided by snowbanks, the home of several microorganisms, especially the dense algal growth that makes the "red snow." This microscopic plant is usually identified as *Chlamydomonas nivalis* and is, surprisingly, one of the green algae. Sometimes it is so dense that it colors the snow pink and gives it a watermelon odor. Its life history, mode of transport, reasons for confinement to high altitudes, and the temperature conditions of the immediate environment all pose some fascinating problems. Knowledge of how this alga can be successful in such a hostile environment might even offer clues for existence beyond the confines of the earth.

Whereas the single species, its function and habits, form the focal point of the physiological ecologist, the plant sociologist, or synecologist, takes as his basic unit the aggregation of various plants in similar habitats and terms them plant communities.

**Flower** spikes of bistort, *Polygonum bistortoides*, may be 18 inches long.

**Large** yellow blossoms of *Hymenoxys acaulis* are common in exposed regions that are free of snow. This member of the sunflower family has short stems.

While there is some overlap between communities, the synecologist usually can readily separate these units on the basis of the predominance of certain species, and the absence or presence of others. For example, most people of the eastern United States know that willow-cottonwood communities dominate the riverbank habitat, and are very different from upland oak-hickory or beech-maple forests. Obviously, these very different environments favor different plant communities. Similar differences exist between upland and lowland tropical rain forests, desert arroyo and flat communities, or ocean bay and slough plankton communities. In each of these cases, the most important environmental feature is different—slope and soil moisture, wind, soil texture, or water salinity.

Tundra vegetation is likewise far from homogenous, and the many distinct communities also result from particular environmental features. In the poorly drained areas, which remain moist throughout the summer, sedges, rushes, and marsh-marigolds predominate. Where it is slightly drier, repent willows enter the community. Where frost hummocks provide protection, the community changes and shrub willows predominate. On wind-exposed slopes the vegetation is more patchy, and cushion plants, certain grasses, and sedges predominate.

THE overriding environmental factor is winter snow cover. Because of the strong winter winds, much of the tundra is snow-free in winter, and under these conditions the climax community is the *Kobresia myosuroides* meadow. The *Kobresia* community is named for its dominant plant, a diminutive sedge that ranges through the Arctic of North America into Siberia. Despite its wide range, it is a relatively unimportant constituent of tundra vegetation outside of Colorado. Perhaps this feature is related to its specialized habitat requirements. It cannot survive, for example, in areas with winter snow cover, or on very exposed rocky fell-fields. Like the giant sequoia, it is ecologically restricted, yet prominent where it does occur.

Under the snow cover are several other communities whose make-up depends on depth of snow, time of melting, and drainage. Snow depth determines the length of the growing season, since it does not melt in many areas until late June, July, August, or even September. Areas where snow melts by the end of June support vegetation almost as dense as that of the *Kobresia* meadow, but later melting results in lowered plant density. If snow patches do not melt until August, only bare rock and gravel remain. The length of the growing season, then, is reflected in the density of vegetation. The dominants of the early melting, snow-covered areas are hair grass, alpine avens, Drummond rush, pyrennaen sedge, and false strawberry, sometimes in mixtures, but sometimes in pure stands. Depressions around the melting snowbanks are often ringed with snow buttercup, an ephemeral but conspicuous plant in early summer. The plant often blooms through the snow and occasionally under it. Blooms have been found under twelve feet of snow. Obviously the plant is active in the very cold, always near-freezing environment of the snow blanket.

In the more open tundra communities, such as the wind-exposed fell-fields, the variety of plant species is astonishing. Owing to the short growing season, and the abundant flowering of most plants, a veritable garden display results in early July. Indeed, had not the "garden of the gods" been applied to so many rock formations as to become trite, it would be most appropriate here. The area in petal surface far surpasses the gorgeous displays of the desert spring or deciduous forest in April. Surprisingly, although

**FLOWER** of *Pedicularis groenlandica* looks like tiny, pink elephant head.

**WIDE-LEAFED** sedge, *Carex scopulorum*, is dominant in snow accumulation areas where snow remains until July and the ground stays moist for entire summer.

the plants are dwarf (most are under four inches high), the blooms are not, and the flowers of moss-campion, sandwort, daisy, avens, cinquefoil, stonecrop, and goldenrod equal their generic counterparts in more favorable situations.

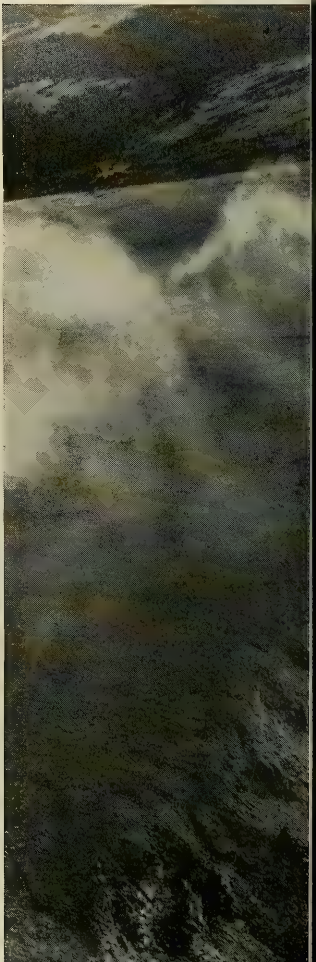
Ecologists study this species diversity in terms of species-area curves, which are based on the number of species found in a given area. Uncovering the exact number of species in a community often requires a taxonomic detective, and is virtually impossible over very large areas. Former studies have indicated that the more favorable the habitat, the more species occur. Thus, the tropical rain forest has more species than a deciduous forest on moist sites, which in turn has more than a similar forest on dry sites. In a study during the summer of 1964 we were surprised to find more species in a small portion of *Kobresia* meadow than we had found in a section of Illinois prairie of the same size. Our assumption that the species-area number would be low in an extreme tundra environment was not borne out, and we must find another explanation.

**Lower flowers on spike of *Polygonum vivaparum* ripen into little "bulblets," which fall, root, and grow into plants.**

**Dark patches on Niwot Ridge flanks are the upper limits of spruce and fir. Ridge size is emphasized by lake below.**

**Clumped and cushion-like, whiproot clover, *Trifolium dasyphyllum, below,* grows to height of about four inches.**

The soil is often the key to plant community distribution, and this may be very clear in the Alps where lime and siliceous soils support very different communities. In the alpine tundra of Colorado, other environmental features mask the role of the soil, and its importance is not always clear. Most tundra soils are very rocky and generally shallow. Under *Kobresia* turf the soil is at least a foot deep, contains few rocks to this depth, and is as black as that found in any Illinois prairie. Dense vegetation is hardly surprising on such a soil. It appears that this soil is depositional and has come from the eroded, wind-swept slopes, a type of tundra loess. The species-richness and vegetation density of *Kobresia* stands could thus be due in part to imported nutrients, much as dense clusters of animals of the rocky open seacoast—



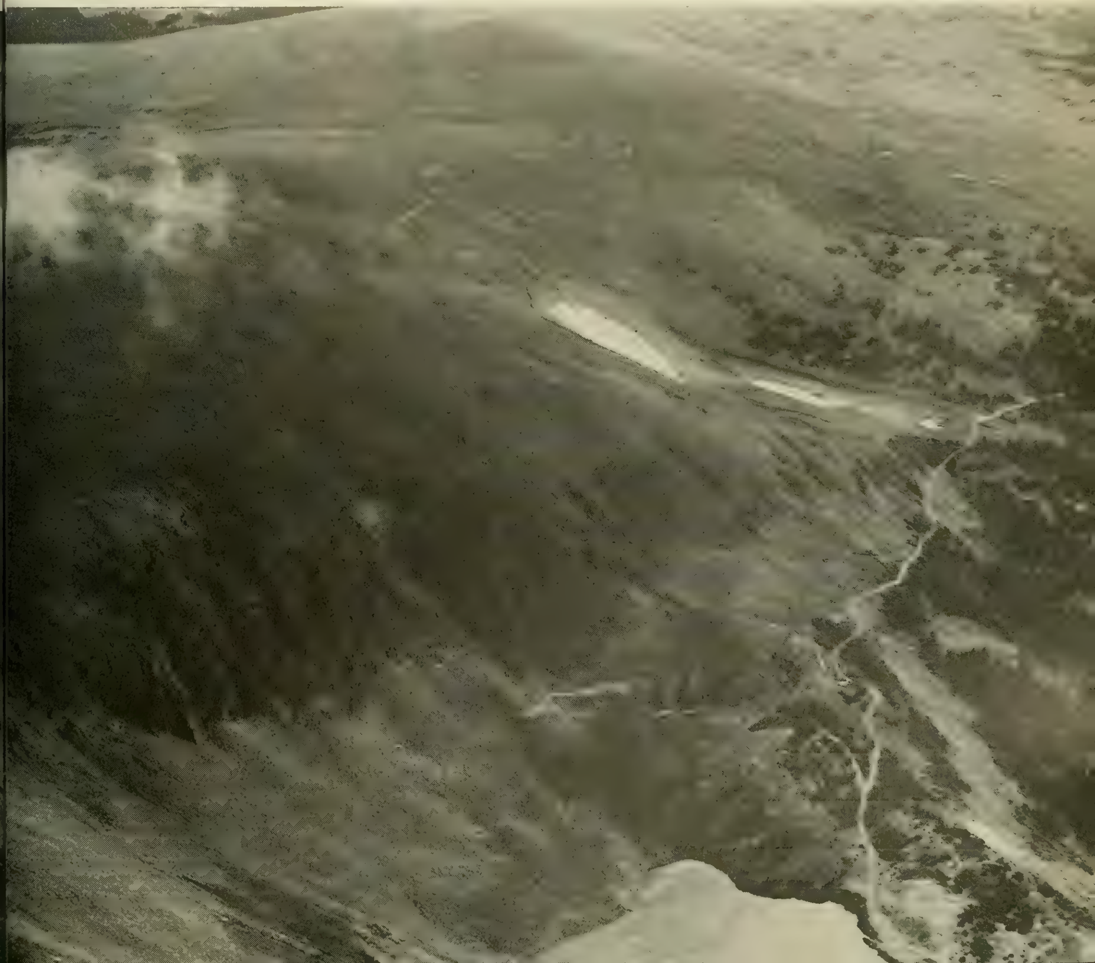
mussels, sea urchins, starfish, and so on—exist on imported food capital washed in by the waves.

But where did this tundra come from? When and how did it get there? Its existence as islands of vegetation on peaks and high plateaus above 11,000 feet is not difficult to explain geologically. The last major glaciation ended only a thousand decades ago and encouraged a cooler climate. This must have lowered the timberline, and hence tundra, and provided continuous connections with the Arctic from time to time as climatic oscillations occurred. Such presumed connections allowed ready plant migration between the two regions. The existence of many circumpolar Arctic tundra species in Colorado provides concrete evidence of these recent connections. However, undoubtedly the two tundras were connected and disconnected many times during the Ice Age, as is indicated by floristic differences that must be the result of long periods of isolation, when extinctions of relatives occurred in both areas.

It has generally been assumed that Arctic tundra developed first, that alpine tundra developed from it in the above manner, and that this development occurred only fairly recently, with the advent of a cold climate at the North Pole. (It usually had been warm enough there to support forest before the glacial, or Pleistocene, epoch.) With tundra vegetation in the Arctic, climatic oscillations during the Ice Age encouraged the migration of these plants down available passageways to similar habitats on mountaintops to the south.

Dr. William Weber of the University of Colorado recently put forth a different hypothesis when he suggested that high altitudes may have been favorable for tundra plants long before the Ice Age; that these plants had evolved at those altitudes before Arctic tundra ever began; and that the Ice Age opened the habitats of the far north to these plants, which then migrated from their mountain refuges. This idea demands that we look more closely at tundra plant distributions, adaptations, and evolution until we can reconstruct their precise history.

History, communities, adaptations, and form, as applied to tundra plants and vegetation, each suggest fascinating questions. They tantalize us now, but answers await further research, which will give us a more thorough knowledge of man's environment.



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# About the Authors

Paul J. Baus, author of "Men, Beeswax, and Molten Metal," has been teaching sculpture in the School of Art at Kent State University, Ohio, for almost twenty years. He has cast bronze sculpture, and has observed the techniques of casting metal in foundries in Antioch, Ohio, at the University of Kansas, and in London and Cheltenham, England. This article on bronze founding is from a book he is writing on the art and crafts of sculpture.

"Mechanics of a Turnover," which discusses a jellyfish's method of turning from one position to another, was written and photographed by Dr. Virgil N. Argo, who has contributed articles regularly to Natural History for several years. He has done biological photography for two decades. Prior to retirement, he was Associate Professor of Biology at The City College of New York.

Dr. Richard G. Van Gelder, Chairman of The American Museum's Department of Mammalogy, is the author of "Channel Island Skunk." Dr. Van Gelder, who has a Ph.D. in zoology from the University of Illinois, has been with the Museum since 1956. He has taught at the University of Kansas and at Columbia University and has done extensive research in mammalian taxonomy, evolution, and ecology.

Dr. Nicholas E. Collias, Assistant Professor of Zoology at the University of California, wrote the article on birds' nests, "Evolution of Nest Building." Dr. Collias has a doctorate in zoology from the University of Chicago, and has taught at Chicago City Junior College, Amherst College, the University of Wisconsin, and Illinois College. His main research interests are in animal sociology and in the study of bird behavior. In recent years he has made an analysis of nest building in birds. The illustrations that accompany his text were drawn by Walter F. Koenig, who is Staff Architect at The American Museum.

"Floras of the Tundra," which discusses the unusual vegetation of the high tundras of Colorado, was written by Dr. Paul D. Kilburn, who has been Associate Professor of Biology at Principia College in Elsah, Illinois, since 1959. Dr. Kilburn studied plant ecology on a National Science Foundation Research Grant from 1960 to 1963, and he now has a 1965-66 NSF Faculty Fellowship for a year's study in England. He obtained the information for this article during several summers' affiliation with the Mountain Field Station of the Institute of Arctic and Alpine Research, University of Colorado.

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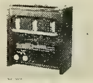

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RESOURCES AND LEGISLATION

# Washington newsletter

By Paul Mason Tilden

Many Americans still think of their nation as relatively youthful and at least partly undeveloped. They might be surprised to learn that the services of a governmental study team have been necessary to identify those few major streams that remain undammed, unchannelized, and relatively unpolluted, either over their entire courses or any of their parts. The findings of such a team form part of the background for a bill introduced in the first session of the 89th Congress to establish a National Wild Rivers System "to preserve, develop, reclaim, and make accessible for the benefit of all the American people selected parts of the nation's diminishing resource of free-flowing rivers."

For many years, conservationists have foreseen the eventual need for the protection of at least a few American streams in their natural condition. The idea began to crystallize a number of years ago during the national water resources investigations by a select committee of the Senate. One of the recommendations of the committee was that "certain streams be preserved in their free-flowing condition because their natural, scenic, scientific, aesthetic, and recreational values outweigh their value for water development and control purposes . . . now and in the future." The committee suggested several rivers that might be preserved, in whole or part, as free-flowing—the Allagash in northern Maine, the Current and Eleven Point in the Ozark Mountains region of southern Missouri, and the Rogue in western Oregon. (The Current River has since been incorporated into the Ozark National Scenic Waterways, along with the Jacks Fork, a major tributary. The Eleven Point was eliminated during subsequent legislation.)

The wild rivers idea gained new impetus when it was endorsed by the Outdoor Recreation Resources Review Commission in its far-reaching report of 1962—the so-called Rockefeller Report, published under the title of *Outdoor Recreation for America.* The ORRRC report had not been in print long before the Departments of Interior and Agriculture named a joint Wild Rivers Study Team. By early 1964 the team had selected twelve streams and had suggested a number of others for consideration. With the team's proposals in hand, the Interior Department made recommendations to Congress during the spring of 1965, and shortly thereafter the National Wild Rivers bill was introduced into Congress by Senator Church of Idaho, with an impressive list of 28 senatorial cosponsors. The Senate Committee on Interior and Insular Affairs, to which the bill was referred for study, held public hearings on the proposal during late spring.

As provided by Senator Church, the following rivers, or parts of them, and some of their tributaries would be included immediately in the wild rivers system: in Idaho, the Salmon, Clearwater, Lochsa, and Selway; in Oregon, the Rogue; in New Mexico, the Rio Grande; in Wyoming, the Green; and in Georgia and Florida, the Suwannee. The bill proposed that a further group of nine rivers or portions of them be studied by the Departments of Interior and Agriculture for possible future inclusion in the system. These were: the Buffalo in Tennessee; Cacapon in West Virginia; Eleven Point in Missouri; Hudson in New York; Missouri in Montana; Niobrara in Nebraska; Skagit in Washington; Susquehanna in New York and Pennsylvania; Wolf in Wisconsin.

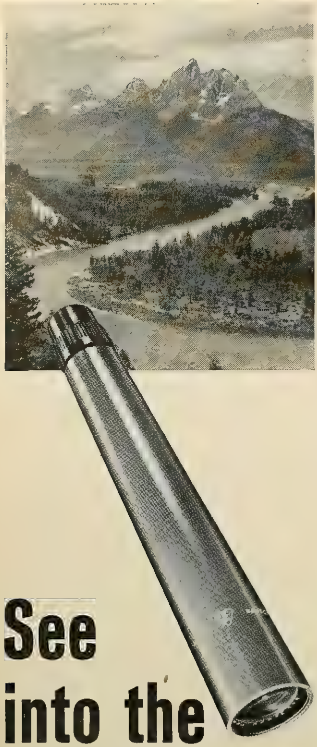
Little public opposition to the national wild rivers idea had developed up to the date of this writing.

## In the National Parks

Two possibilities for national parks are currently under serious consideration either in Congress or in conservation circles—the Guadalupe Mountains National Park in Texas and the Redwood National Park in California. The two areas differ greatly, both in their physical characteristics and in their prospects for being incorporated into the national park system.

Within the northern portion of the part of western Texas that underlies New Mexico—sometimes called trans-Pecos Texas—lies the Guadalupe Mountains range, an eastward-tilted fault block that rises to nearly 9,000 feet in Guadalupe Peak, its highest point. The range is the culmination of a great limestone plateau trending south out of southern New Mexico. The sheer walls of the plateau's southern terminus, imposing El Capitan, constitute a textbook cross section of reef building by Permian marine algae; in fact, the entire area proposed for the park is a splendid monument to the history of the Permian geological period.

Geological interest is, however, insufficient in itself to qualify an area for



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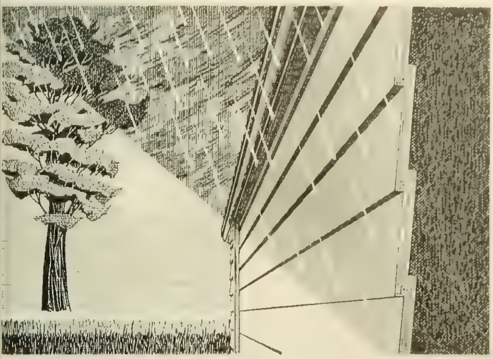

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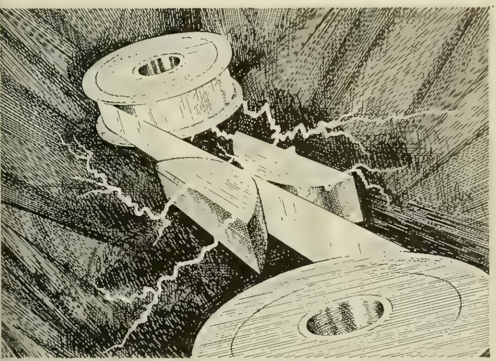

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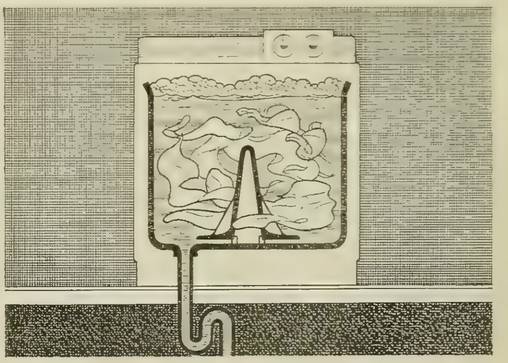

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national park status; the region must also possess great scenic and biological merit. The scenery of the Guadalupe Range is superb in a stark and naked way—somewhat similar to that of existing Big Bend National Park many miles to the south on the Rio Grande. In flora and fauna, however, Guadalupe's diversity is greater, running the gamut of biological life-zones from Chihuahuan desert to Canadian.

Almost all of the 71,000 acres proposed for inclusion in the park lie within the "Texas-sized" ranch of J. C. Hunter, Jr., who has indicated his willingness to sell the land to the Government for less than he might obtain from a private buyer. The park would include at its northeast corner the McKittrick Canyon special scientific study area of 5,632 acres, which was donated to the Park Service several years ago by ranchman Wallace E. Pratt.

It is a matter for some wonder that, out of the nearly two million original acres of California's world-famed and botanically remarkable coastal redwood, *Sequoia sempervirens*, relatively few acres (Marin County's 500-acre Muir Woods National Monument) have been preserved within the national park system. With the help of private organizations—notably the Save-the-Redwoods League—and philanthropic individuals, plus a generous attitude on the part of some of the redwood lumber companies, California has over the years put together a splendid system of state redwood parks. These now number 28, and include more than a hundred thousand acres of redwood lands, of which nearly fifty thousand acres are in virgin growth and "monumental" groves — a tremendous tribute to the aesthetic awareness of a nation that in the past has had to measure its natural resources largely in terms of dollars.

And yet, splendid as the work is that has already been accomplished at the state level, there is still no large-scale federal preservation devoted to the coast redwood—one that would protect not only a magnificent and major representative redwood forest and its associated flora and fauna but the entire watershed system of the forest.

In April, 1963, the National Park Service received a grant from the National Geographic Society for a special study of the coast redwoods and their present status, looking toward the possibility of additional preservation. In the fall of 1964, the Service published an exhaustive preliminary analysis of the coast redwood belt—its economy, geology, flora and fauna, history of its early human settlers, and its potential as a major redwood park. Such a park, it was said, might be located in the Redwood, Lost Man, and May Creek watersheds of Humboldt County, enclosing some 53,600 acres of outstanding redwoods, of which more than 20,000 acres would be virgin growth. The federal park would include California's Prairie Creek Redwoods State Park, which would be enlarged by purchase of present inholdings, plus additional lands along the yet-unspoiled Pacific shoreline. The Park Service also outlined two alternate, smaller parks in the same general area, progressively omitting larger portions of vital drainage-basin lands.

As might be expected, most conservationists reacted swiftly and favorably to the Service's so-called Plan 1; that is, the most expansive and, by all odds, the most expensive proposal. (Estimates of a quarter-billion dollars have been given for establishing the Plan 1 park.) Also, as might be expected, the redwood lumber industry reacted strongly, but in the opposite direction, saying that there were already sufficient old-growth *sempervirens* under protection. To further complicate the situation, some conservationists thought that the best place for a federal park was in the splendid redwoods of Del Norte County, farther up the California coast.

As of this writing, the redwood national park idea is in thoroughly chaotic condition. But some definitive plan will undoubtedly be forthcoming in the months ahead, for the President has taken an interest in the matter, and has requested the Secretary of the Interior to submit some final recommendations.

## Monument to Miocene Mammals

SINCE this column last appeared, Congress has authorized the addition to the nation's park system of a splendid scientific monument. The Agate Fossil Beds National Monument, 3,150 acres on the upper reaches of the Niobrara River in western Nebraska, will protect and interpret for the public an outstanding concentration of fossilized Miocene mammalian remains. The deposit has been under exploration by American and European paleontologists for nearly three-quarters of a century, and still contains a treasure of scientific material. Over the years, much scientific literature has focused on the Agate Springs fossil beds; reports of explorations and findings have appeared in a number of past issues of NATURAL HISTORY magazine and other publications of The American Museum of Natural History, and in the journals and papers of many other museums, universities, and scientific organizations.

The main objective of the National Park Service at Agate Fossil Beds is to preserve the quarries for public interpretation. Fossil beds will be prepared *in situ* for display, with an opportunity for the public to follow the processes of excavation and the reconstruction of mammalian remains. A secondary aim

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will be preservation of a representative portion of the Niobrara River and its blufflands; for the high-plains, shortgrass matrix of the monument possesses a certain somber beauty of its own—treeless and monotonous to the eastern eye, perhaps, yet bejeweled in season with all manner of wildflowers, and relieved by the occasional river-bottom greenery of cottonwood and willow.

To some visitors the human history of the Agate Springs fossil bed locality will also prove fascinating. The land to be acquired for the preservation lies for the most part within the old ranchland holdings of Captain James Cook, great-grandson of the English explorer and navigator. The great-grandson was a western pioneer who had variously been cowboy, big-game hunter, scout in the Army's campaign against the Apache leader Geronimo, and an intimate friend of the Sioux and Cheyenne. It was in 1878, after the Captain had taken up the more prosaic business of cattle ranching in western Nebraska, that he located the weathering outcrops of fossil bones that were to lead some years later to world-wide renown for the locality. Cook had a working acquaintance with the science of paleontology, and his interest in the find eventually brought the beds to scientific attention. His son, the late Harold J. Cook, later made the ranch a headquarters for visiting paleontologists and initiated a campaign for public preservation of the area as a scientific monument—a campaign taken up by his wife, Margaret Cook, after his death. Mrs. Cook has agreed to donate for display and use at a monument museum the family collection of Indian artifacts and historical material and her husband's large paleontological library.

Two other preserves of a related nature are currently under consideration by the Congress: the proposed Fossil Butte National Monument just west of Kemmerer, in southwestern Wyoming, and a possible Florissant Fossil Beds National Monument, 35 miles west of Colorado Springs, Colorado. The first site was suggested primarily to preserve the wealth and perfection of its fossil Eocene fishes. The second would protect a classic locality of fossil insects and plants of the Oligocene. Fossil Butte would encompass 8,240 acres of fossiliferous Green River shales and limestones; Florissant would contain 6,000 acres of high intermontane basinland, which, during the geologic past, was subjected to numerous volcanic ash falls, now evident as thinly-laminated, fine-grained shales bearing a wealth of fossil insects, plant leaves, and other relics of the Oligocene Epoch.

No particular opposition has developed to either proposal; in fact, both have considerable support in their local areas. It is also true, however, that pro-

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posals for small scientific preserves of this kind are viewed in Congress as having relatively minor importance, and their consideration must await disposal of major issues of the day. Patience on the part of conservationists and scientists is indicated in both instances.

## Threatened Animals

Since 1937, when the first official effort to prevent the extinction of the whooping crane was made by establishing the Aransas Wildlife Refuge on the coast of Texas, the Fish and Wildlife Service has constantly and effectively publicized the plight of *Grus americana*. While the whooping crane population fluctuates from year to year, 42 of the big birds left the safety of Aransas in the spring of 1965, and headed for nesting grounds in Canada's far-northern Wood Buffalo Park. This was ten more than had made the trip during the preceding spring, a figure that seemed to offer a measure of encouragement.

Less well publicized, however, is the plight of hundreds of other American animals — mammals, birds, fishes, and reptiles. Many of these are likely candidates for extinction in the immediate future; others may live on for years or perhaps even decades, although in constantly declining numbers. There are today not less than 16 species of American mammals, 25 of fishes, 34 of birds, and one reptile whose future outlook is very dim; there are scores of others whose likelihood of viability is either marginal or suspect, but is not sufficiently well evaluated to pronounce upon. One mammal among the definitely threatened is the Kaibab squirrel, tassel-eared inhabitant of some 2,100 square miles of habitat on the north side of Arizona's Grand Canyon. The Kaibab recently caused a severe misunderstanding between conservationists and the Arizona Game and Fish Commission.

For years the Kaibab squirrel, viewed by many zoologists as one side of an interesting evolutionary pair (the other member being the Abert squirrel, with a larger territory on the south and east of the Colorado's great chasm), has been under the legal protection of Arizona. Then, in the fall of 1964, it was announced that there would be an open season on the Kaibab in conjunction with Arizona's annual wild turkey hunting dates. In tart exchanges with the Commission, conservationists all over the country came to the defense of the mammal, pointing out the inadvisability of incurring further losses among the thousand-odd remaining squirrels. They also pointed out that the National Park Service, whose Grand Canyon National Park forms a protected part of the animal's habitat, was currently making a scientific study of the animal's condition to determine why its numbers were decreasing, and to insure, if possible, the restoration of a "normal" population. (What such a population might be is at present not well known, but in any event, the scientist in charge of the study reported that his research was retarded by the very scarcity of the mammal.) The National Forest Service, which administers the balance of the habitat, is legally helpless to assist, since game in the national forests is under jurisdiction of the states. One conservationist charges that the Arizona Commission has wholly capitulated to the pressures of organized hunting, and that in so doing it has abdicated its responsibility for the protection of a native species of great aesthetic charm and national and international scientific value.

**Mr. Tilden, a writer and an editor in the nation's capital, often contributes columns that pertain to government legislation and our natural resources.**

At almost the last minute the Commission somewhat ungracefully canceled the hunt. It promised, however, that it would consider an open season on the Kaibab squirrel in the fall of 1965. Conservationists were not sure whether or not the promise was intended as a face-saver, but they indicated that a collective conservation eye would be kept open in the matter.

Some Congressional interest has been evidenced in the more general issue of threatened native animals; in particular, Senator Mundt of South Dakota has introduced a bill to finance a wildlife research project at Patuxent, Maryland, directed by the Bureau of Sport Fisheries and Wildlife, "to save . . . rare and endangered American wildlife species."

## Question of Economy

Conservationists and the nation's sporting fraternity, at odds from time to time, recently found themselves in agreement over an issue affecting the national wildlife refuge system. The issue was the Budget Bureau's proposed reduction in size, or complete elimination of, eleven wildlife refuges widely scattered about the country. Neither conservationists nor sportsmen, who have invested millions of dollars in the refuge system by way of annual "duck stamp" purchases, were pleased.

The proposed action was advanced by the Bureau of the Budget in the name of economy, but scrutiny of the sums to be "saved" seemed to make a rather unconvincing case. Example: the Bureau proposes abolition of the 49,000-acre Carolina Sandhills Refuge in South Carolina, on which half a million dollars was spent not long ago for wildlife habitat improvement, in order to save $37,000 a year and eliminate two permanent jobs. The refuge offers prime habitat or deer, wild turkey, and quail, to say othing of its intangible value for huian refugees from city and town. Exmple: elimination of the Piedmont Vildlife Refuge in Georgia in order o save $44,000 annually. This refuge rought into the Federal treasury $124,00 from timber sales in 1964, in addiion to functioning as a wildlife refuge. xample: elimination of the Monomoy Vildlife Refuge on Cape Cod in Massahusetts by adding it to the adjacent ape Cod National Seashore, at a saving f $13,000 and one permanent job a ear. The Monomoy Refuge is a most mportant one for migratory waterfowl nd various shore birds; acquisition by he Park Service could mean road buildng and recreational development under he current "people serving" managenent philosophy of the Service.

Certain of the acreage reductions and ne or two of the eliminations might be ustified, conservationists thought, but n the whole the program seemed to arry "economy" to extremes. Senator letcalf of Montana, a member of the ligratory Bird Conservation Commision, which has primary responsibility or creation of national wildlife refuges, pparently was of this opinion; he has ntroduced into the Senate a bill that vould amend the Migratory Bird Conervation Act, upon which the wildlife efuge system is based, to require Conressional approval of the sale, transfer, r other disposition of lands acquired by he Commission.

## Some Concrete Proposals

SPRING and summer bring a profusion of flowering plants into bloom along he Potomac, and a corresponding infloescence of Congressional bills for the onstruction of various "scenic parkvays." This year has been no exception o the rule. Thus, there have already een proposals for an Ohio River Parkvay in Indiana, a Great Prairie Parkway n Kansas, a Sierra Way in California, nd a scenic highway connecting the hree units of Theodore Roosevelt Naional Memorial Park in South Dakota. dditionally, six federal agencies have ollaborated in concocting a plan for ,600 miles of parkway in Virginia, and 00 miles in Maryland. California talks bout a scenic parkway that would tie ll the redwood state parks together, nother penetrating the high country of osemite National Park, and yet anther into the *Sequoia gigantea* groves f Sequoia National Park. These would e in addition to the various scenic parkvays and highways that have been proosed to lace Appalachia under the proram of the war against poverty, and vould be accomplished with the aid of ederal funds. Conservationists wryly oberve that the natural scene annually eems about to be encased in concrete.

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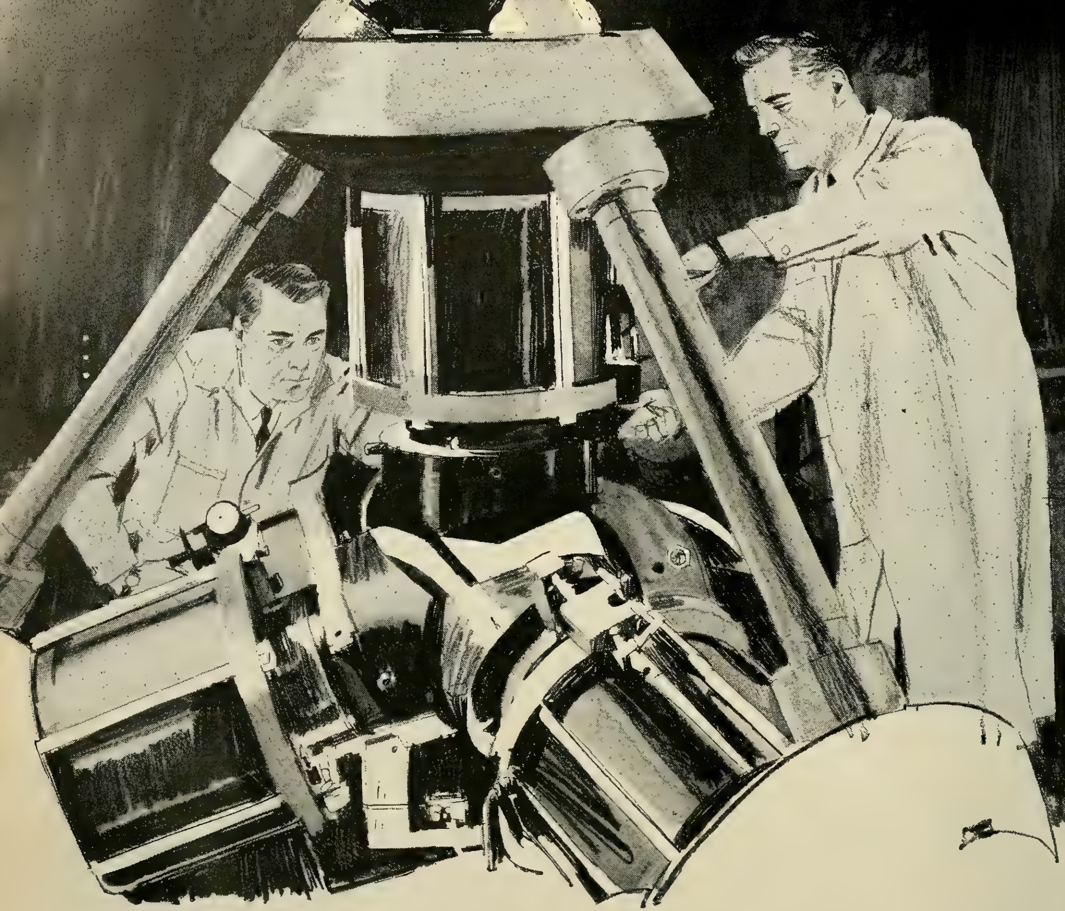

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SCIENCE IN ACTION

# Mixing oceans and species

By Ira Rubinoff

THE Central American region has long been of interest to biologists because f the presence of extremely similar opulations of marine organisms along he Atlantic and Pacific coasts. In some ases, these Atlantic and Pacific popuations are completely indistinguishable, lthough others have evolved minor diferences and a few have changed prooundly since they became isolated by he rise of the Central American isthmus. The Isthmus of Panama, while acting as landbridge for the exchange of North nd South American terrestrial fauna, s a barrier to marine organisms—a barier that has remained impenetrable to ll species but the few that are able to ransgress the fresh-water canal comleted in 1913. The precise date at which n uninterrupted isthmian landbridge merged is not known. Most scientists gree that the water gap was finally losed during the latter part of the Pliocene. This would mean that the maine populations have remained sepaated for more than five million years.

This relatively recent interruption of he continuity between faunas of the Atlantic and Pacific has resulted in parallelism between many of the forms n the two coasts. These closely related allopatric species (those that do not have overlapping geographic ranges) have been referred to by a number of designations: "geminate species," "species pairs," "analogous species," and "amphi-American species." The parallelisms have been reflected in both the vertebrate and invertebrate faunas.

The degree of morphological similarity between fishes varies among species. Among the grunts, *Haemulon steindachneri* is considered to be identical in both oceans. Other grunt species pairs, such as *Anisotremus surinamensis* in the Atlantic and *A. interruptus* in the Pacific, are difficult to separate. Other Atlantic and Pacific species can be separated with relative ease, although they are obviously closely related. Similar examples are also found in shallow-water groups of echinoderms, crustaceans, mollusks, and even parasitic trematodes.

The fact that there are so many similar species is somewhat surprising in view of the vastly different habitats the two coasts offer. The Pacific coastal waters of Central America have a higher tidal amplitude and in general are more silty than the waters off the Atlantic coast. Also, some Pacific areas are subject to upwellings of cold water not found in adjacent areas of the Atlantic. These factors contribute to limiting the growth of coral reefs along the Pacific mainland coast, while such reefs are abundant on the Atlantic side.

## Problems of Access

NOW that a sea-level canal across Central America is contemplated, some interesting biological problems are posed. No one, of course, can tell what the effects of such a canal will be. Certainly, the construction would represent an artificial removal of a geographical barrier that would undoubtedly result in the mixing of the two faunas with unpredictable effects. What will happen when the closely related species on either side of the isthmus are allowed to mingle? Will one or the other be exterminated? Will they hybridize? If so, with what consequences? Theoretically, the results of the sudden intermixing of two formerly isolated populations can be predicted according to certain ecological and genetic principles.

Ecological problems are those concerning competition for food, and space to live and breed. Interference may be direct—by the activities of one species against another—or indirect—through the influence of parasites or diseases of one species upon the others. These complex, competitive factors are frequently difficult to interpret. An example of this is the interaction between the introduced American gray squirrel (*Sciurus carolinensis*) and the native red squirrel (*S. vulgaris*) in England (NATURAL HISTORY, December, 1964). In some parts of that country the gray squirrels have posed serious threats to the native red squirrels, while in other areas the red squirrels are still holding on.

The potential for interbreeding between the newly intermixing populations will depend upon whether or not they have diverged genetically during their isolation in ways that have made them reproductively incompatible. Such changes, referred to as isolating mechanisms, can be inherent in populations that have no corresponding externally correlated features. Two isolated populations, although morphologically identical, may be incapable of gene exchange.

Not every allopatric population has necessarily completed speciation, and it is expected that some populations might successfully fuse with their related allopatric populations if the geographical barrier were removed. Depending upon

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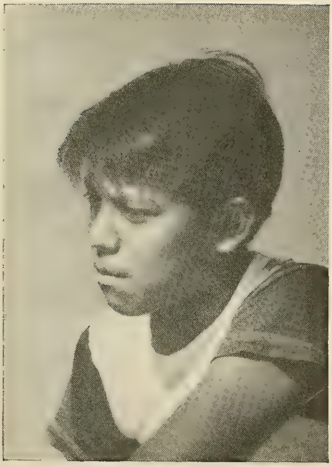

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the level of reproductive isolation and the ecological, behavioral, and genetic adaptations that have been achieved in isolation, the effects of allopatric populations coming into contact with one another may be classified into the following, not necessarily exclusive, categories:

(1) If during the period of allopatry no isolating mechanisms were developed, the populations may freely interbreed, producing a viable hybrid swarm. This swarm may eventually include the complete range of variability of both parental populations or it may be limited to a narrow hybrid belt. The extent of such a hybrid belt will be determined by the ability of the hybrids to adapt ecologically to the geographic ranges of both parental populations.

(2) The newly sympatric populations (those with overlapping geographical ranges) may freely interbreed, but if their gene pools are not sufficiently similar, then adaptively inferior hybrid swarms may result, and these could lead to the extinction of both populations.

(3) If the development of reproductive isolating mechanisms between two populations was begun but not completed in isolation, then occasional matings between individuals of the populations may be expected. These matings may be sterile, or the progeny may be inviable or sterile. In this case, those individuals whose behavior insures their mating only with others of their kind will be reproductively more successful, and isolating mechanisms will become more prevalent throughout the populations. Selection will act to improve the efficiency of some of the isolating mechanisms so that the two populations continue to remain separate. If, on the other hand, the occasional crossings between two populations does not produce adaptively inferior progeny, the populations may react as in the first category, but somewhat more slowly.

(4) If the isolated populations have completed speciation before they mingle, they may coexist without interbreeding for part or all of their ranges, or if their isolating mechanisms do not include ecological factors, competition between the two forms may cause replacement or extinction of one species by another.

From the various degrees of morphological divergence exhibited by the amphi-American species of shore fishes I have studied, one should be able to predict that different groups will react in almost all the ways enumerated above.

## Study Proposals

Several sorts of studies should precede the construction of a sea-level canal if we are to have any hope of predicting the effects of faunal mixing. First, we must understand the levels of reproductive isolation that have been achieved by populations living on the opposite coasts. Ordinarily, reproductive isolation is a criterion that is readily established only in sympatric populations, where one can easily see if two populations interbreed. In Central America, however the problem is much more difficult, because the populations in question are kept separated by a natural barrier. We can assay the potential for interbreeding between the Atlantic and Pacific populations in two ways: directly, by experiments attempting to interbreed related species from both coasts; or indirectly, by associating the degree of reproductive isolation with the number of morphological, ecological, and behavioral differences exhibited. Allopatric species that are morphologically very similar are considered to be more likely to interbreed than those with greater differences. By rating the populations on some kind of similarity index, a measure of the potential for gene exchange between related populations could be obtained. However, the levels of genetic and morphological divergence are usually, but not always, closely correlated, so an indirect method based on such an index is of limited reliability. Our current knowledge of marine fishes and invertebrates is too inadequate to allow an interpretation of the evolutionary history of most species or a prediction of their future.

If the barrier is removed, some ubiquitous species certainly will expand into new areas. These may successfully exploit these areas to the point of causing the extinction of less adaptable species. Many of the species that become extinct may be part of the relatively large portion of the Central American fauna that is either undescribed or extremely rare in collections. Their extinction would be a great loss to scientific knowledge.

Even if more information on the results of population mixing were available, there would still be one serious limitation to the reliability of predictions based on such information. The construction of a sea-level canal will change the physical and biotic environments on the respective coasts. These changes will require the resident populations and the newly immigrating populations to make rapid adaptations. The influx of new organisms could upset the balance of populations, and certainly would change the nature of the selection to which the organisms are subjected. The physical changes in the environment probably will be of a more local influence, their extent depending largely on the volume of interocean flow and on the accompanying differences in temperature, salinity, and silt. It is in such "disturbed habitats" that the breakdown of previously existing isolating mechanisms often permits the hybridization of numerous terrestrial species.

Even if isolating mechanisms have evolved in most of the amphi-American species, considerable study must be unertaken before we can hope to predict ne ecological effects of the sudden coexstence of two closely related and previusly separated species. If the two forms nhabited similar niches on their respecve coasts, they would be expected to ompete for available habitats. Under uch circumstances, the species already esident and established in a region ould be expected to resist the intrusion f immigrants from other regions. Howver, if the environment is changed, as it vell may be, then the small populations f immigrants conceivably could be in a etter position to adapt to the changed nvironment, and consequently might nultiply and eventually exclude the preiously extant species.

### Migration Deterrents

WHAT can be learned by studying the history of the man-made connecions of great bodies of water? The situaion of the sea-level canal connecting the Iediterranean Sea and the Red Sea is ot similar to that which is planned for Central American site. The Suez Canal ontains the Bitter Lakes and other odies of water of very high salinity and igh temperature. In spite of these harsh onditions, some marine organisms have ucceeded in transversing the Suez Canal ince 1869. Many Indo-Pacific species rom the Red Sea have now penetrated hrough the canal into the eastern Medierranean (a total of thirty species of shes comprising approximately 5½ per ent of the total Mediterranean fauna. ccording to a recent compilation). Many f these species are showing measurable hanges as a result of their adaptations o new environmental conditions. Some, uch as the commercially important goatish (*Mulloidichthys auriflamma*) and he rabbitfish (*Siganus rivulatus*), are noving west and are now found in the Aegean Sea.

The migration of other organisms hrough the canal has also been more or ess limited to one-way traffic. The Camridge Expedition to the Suez Canal in 924 reported that only two of the sixeen species of crabs they found in the anal were of Mediterranean origin. The ighly saline waters, together with the rimarily northerly directed current in he canal, have essentially limited disersal to a south-to-north direction. Adlitional factors also operate to prevent Mediterranean fauna from moving into he Red Sea. Biologists consider the igher temperature of the Red Sea and he numbers and diversity of the extant auna to be important factors in preventng immigrants from taking hold.

The present Panama Canal also repreents a potential interocean passageway or marine fishes, as they are free to nter the locks with the ships. However, he fresh waters of Gatun Lake, through which marine fishes must pass in order

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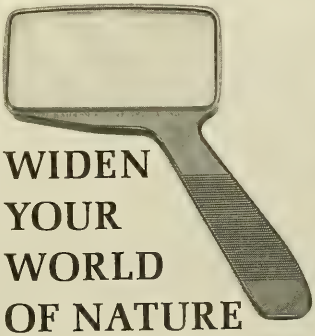

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to transit the canal, have remained an effective barrier to all but the most widely adaptable marine species. The most notable immigration that has occurred in this area is the occasional passage of the Atlantic tarpon (*Megalops atlanticus*) into Panama Bay on the Pacific coast of Panama.

The proposed Central American sea-level canal would not act as an effective barrier; in fact, the tidal differential between the respective coasts would, under certain conditions, tend to wash populations from one ocean into the other. Under these circumstances, the opportunities for successful immigration and interoceanic dispersal of many species is almost certainly assured.

## Dangers of Introductions

The history of man's voluntary and involuntary introductions of animals into areas where they did not previously exist indicates that, as often as not, the results have been disastrous. One need only mention the famous cases of the Dutch elm disease, the house sparrow, the starling, and the gypsy moth in North America; the mongoose in the West Indies; the red deer in New Zealand; and the rabbit in Australia. Some of these unwanted invasions have been controlled or eradicated by expensive human counterefforts. Occasionally the introduction does not become a nuisance for a long time. It took approximately one hundred years for the population explosion of the sea lamprey to occur. When the Welland Ship Canal was opened as a bypass around Niagara Falls it removed the barrier that had previously prevented the sea lamprey from penetrating the western series of Great Lakes. The eventual decimation of the whitefish and lake trout populations that resulted is only just now being controlled. The cost of this control research, as well as the loss to the fisheries of the Great Lakes region, is a vivid example of the economic effects that can result from inadvertent introductions.

Some introductions have the desired results, as illustrated by the establishment of the striped bass (*Roccus saxatilis*) off the coast of California or the successful introduction of the Gray Partridge (*Perdix perdix*) and the Ring-necked Pheasant (*Phasianus colchicus*) into North America. However, attempts to introduce European songbirds into North America have largely failed. These examples illustrate our general ignorance concerning the dynamics of population introductions.

A sea-level canal, however, will not provide every species with a free pass to a new ocean. For example, as a result of the environmental differences between the Atlantic and Pacific coasts, particularly in the abundance of reefs, many organisms more or less dependent upon corals would not be capable of penetrating the Pacific rapidly. We can expect that for species with narrowly restricted ecological niches, the opportunity to extend their ranges may not be exploited. However, for most species the hydrographic conditions on the respective coasts are about equally hospitable, and would not present a severe obstacle to the dispersal of populations.

Finally, we must be concerned not only with the fate of the fish populations but also with the invertebrates, the flora, the movements of parasites into new areas, and the possible effects of silt influxes on Atlantic reefs. We see, then, that there are many parameters to this problem. Without question, the construction of a sea-level canal in Central America represents an important experiment, but its full scientific value can only be realized if it is carefully controlled. A complete and thorough pre-canal survey on the same order of magnitude as those studies conducted in connection with the International Indian Ocean Expedition could be one important step. This would make it possible to evaluate properly the changes in the physical and biological environment that are produced by the canal. A comprehensive survey of levels of isolation achieved by the respective populations also would help us to determine intelligently what measures, if any, it may be necessary to incorporate into the new canal, either to inhibit or to prevent the interocean exchange of species. Such surveys and studies would contribute immensely to our basic scientific knowledge of a relatively unexplored area. In addition, they could serve to lessen the probability of our inadvertently permitting the interoceanic introduction of species that might have detrimental effects on extant fish and fisheries.

Dr. Rubinoff is with the Museum of Comparative Zoology at Harvard as a Research Fellow in Ichthyology.

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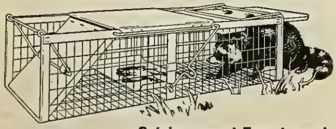

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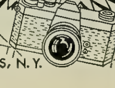

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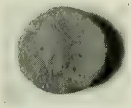

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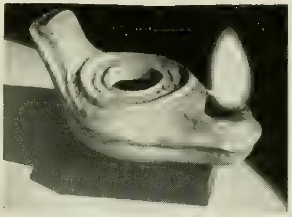

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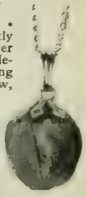

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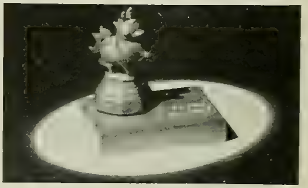

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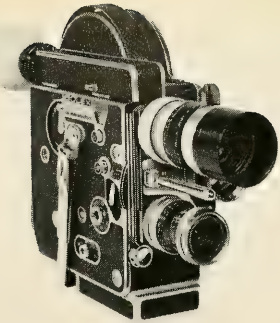

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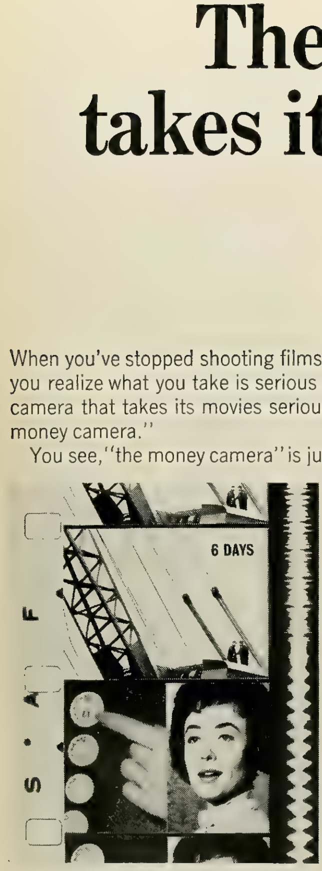

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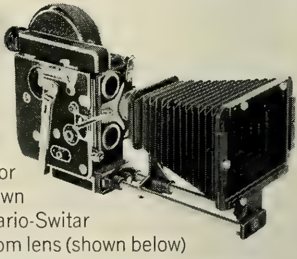

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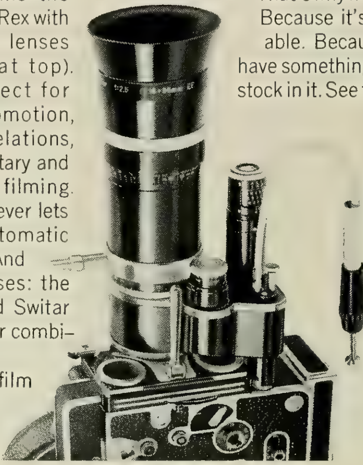

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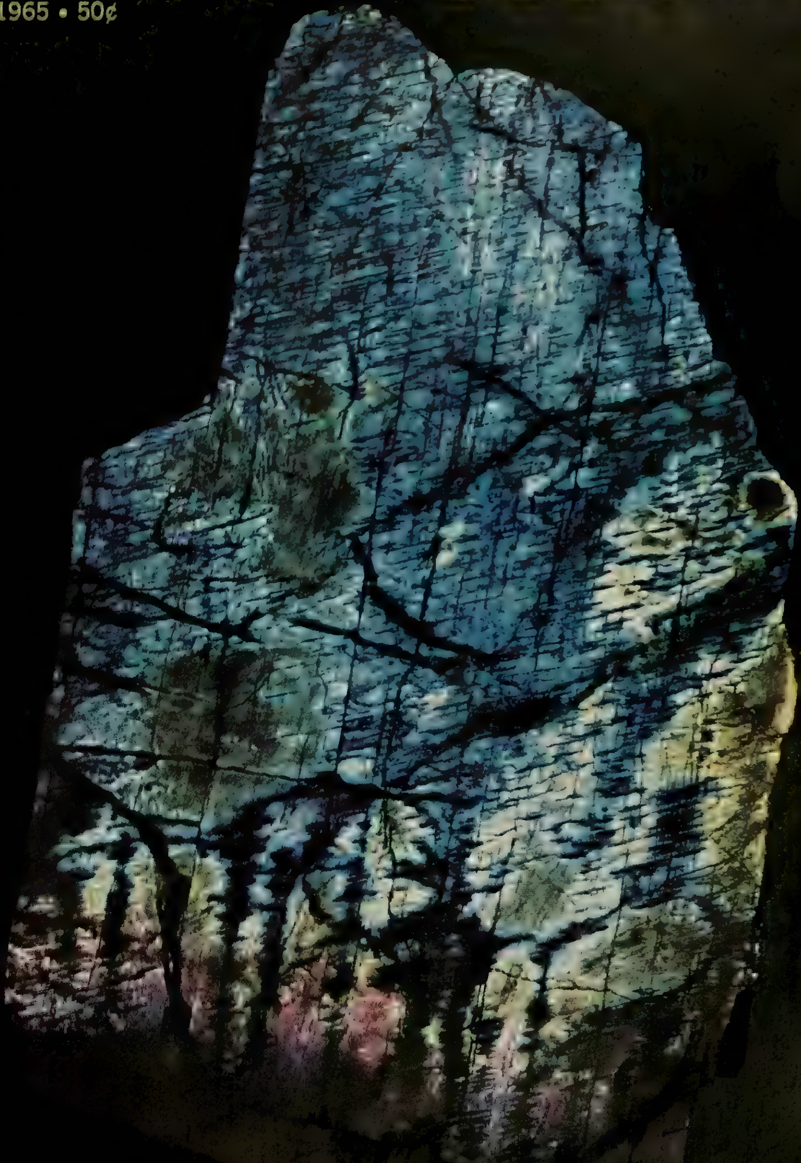

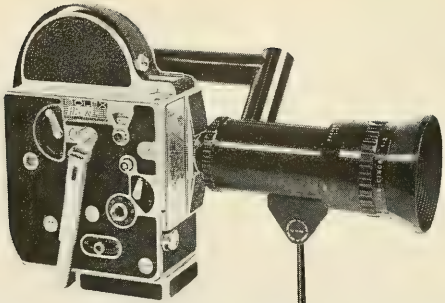

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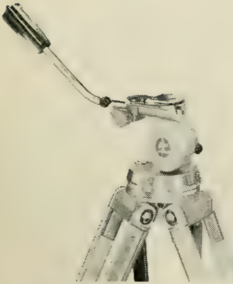

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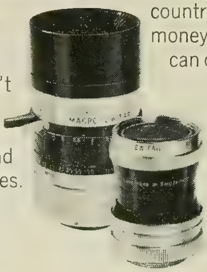

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# Natural History

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*THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY*

Vol. LXXIV OCTOBER 1965 No. 8

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COVER: Paul E. Desautels, in the article that begins on page 52, discusses the dramatic visual effects that are seen when some minerals are viewed under suitable types of lighting. The mineral shown on the cover is a gem variety of plagioclase feldspar known as peristerite, and was photographed under ordinary white light. The blue glow, or schiller, exhibited by this specimen is caused by interference—light being acted upon by the thin films or plates that occur in the structure because of a mineral phenomenon called twinning. Peristerites such as this are found in Canada and elsewhere. Photographs are by Lee Boltin.

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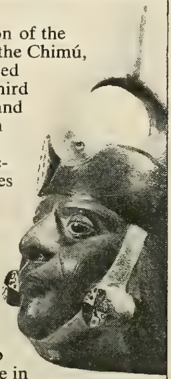

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# Art in a new context

### By Douglas Newton

Australian Aboriginal Art, edited by Ronald M. Berndt. *The Macmillan Co., $17.50; 117 pp., illus.* The Rock Art of South Africa, by A. R. Willcox. *Thomas Nelson & Sons, $18.00; 96 pp., illus.* Wantoat, by Carl A. Schmitz. *Humanities Press, $8.00; 159 pp., illus.*

At one point in his book, *Wantoat*, Carl Schmitz complains of the way that exhibition designers deal with works of primitive art. "Placed on pedestals, in glass cases, or suspended from the ceiling," he says, they convey little or nothing of their natural surroundings. As a museum worker whose job includes placing such works on pedestals, in glass cases, and suspending them from the ceiling, I sympathize. but I have long since accepted this difficulty. I do so with all the more fortitude since the same thing applies equally to such familiar works as the "Mona Lisa," *Hamlet*, and the Pantheon. All are victims—if one wishes to put it that way—of the irreversible processes of history. Any work of art removed from its "proper" context becomes to some extent a different creature. Yet, simultaneously, it begins to enrich the new context itself. The degree of enrichment depends to some extent on the degree to which we participate imaginatively in its original circumstances. How are we to do this? To paraphrase an apt quotation Schmitz gives from Schelling, we must not adapt the phenomenon to our own inflexible principles, but must enlarge our ideas to be commensurate with the phenomenon. Philosophically, this may raise difficulties; practically, one can make a start by acquiring the kind of information about exotic cultures that we have about our own. This is indeed the latest strategy for tackling the subject and, in varying degrees, it is exemplified by each of the books under review.

When primitive art first began to be taken seriously (as the result of a change-over from the idea that these products of barbarous societies merely reflected that barbarity and were correspondingly beneath consideration), it was widely accepted that the primitive artists were unschooled, impulsive, and intuitively creative. This misconception came to be tempered by another one. The discovery that certain forms were made for definite purposes, and therefore were continually repeated, led to the idea that the artists were dominated by tradition and that any attempt at divergence from it was controlled by strict prohibitions. The anthropologists, who should have known what actually went on, were of little help. The development of their science along sociological lines led to plain neglect of the role that art plays in society. Hence we are still much more ignorant on this topic than we should be.

Here, however, we run into a paradox. Over the last few years there has been a growing conviction that it is not enough to appreciate the phenomenon of primitive art: before we can "enlarge our ideas to be commensurate with it," we must know all the facts surrounding it. The hope is that, as a basis for a realistic degree of appreciation, our intuitive sympathy will become in some degree similar to what it is for our own culture. Presumably nobody enters into this effort with any expectation of complete success. To do so is to court the fate of the unfortunate person, mentioned in Ronald M. Berndt's section of *Australian Aboriginal Art*, who "standing in front of a bark painting claimed that he could not appreciate it fully, because he had been told that to do so he must know its meaning; in accepting the warning, he found himself unable to enjoy such a painting in the same way that he would others. . . ." I doubt that this is an uncommon experience, and I suspect it may become even more common. It is certainly true that a number of recent books on various aspects of primitive art give the impression that their authors know all about the subject except one thing: whether the works discussed are beautiful. This, happily, is not the case with any of the authors of the present books.

*Australian Aboriginal Art* is a dazzling and monumental work; its contributing authors include practically everyone who knows anything about the subject—R. M. Berndt, A. P. Elkin, F. D. McCarthy, T. Strehlow, C. Mountford, and J. Tuckson. All of its many plates are in color. As far as the large-scale art-book repertoire is concerned, it deals with a relatively unfamiliar subject—one neglected particularly, it appears, in Australia itself, where interest has only dawned in the last twenty years. (At this point, incidentally, the interest is taking a rather disagreeable turn; adapted aboriginal designs are appearing on souvenirs, ceramic ashtrays, table lamps, and the walls of coffeehouses.) This book should go far toward being a corrective and a stimulus. It is probably the handsomest book on the

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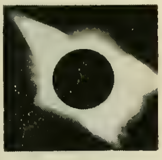

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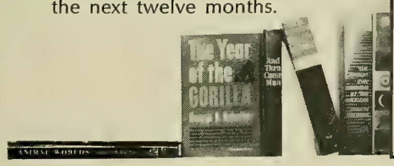

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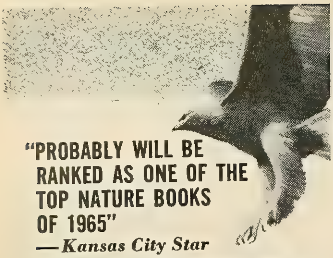

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subject so far and certainly one of the most attractive, although not the best balanced. The rock engravings are decently represented, the rock paintings less adequately. The book's real strength lies in its many reproductions of bark paintings, nearly all from Arnhem Land. These are well selected to illustrate the variety of styles and subjects, and they are, of course, the greatest showpieces from the continent. It should have been possible to show more of the Queensland painted shields and to convey somehow the quality of the abstract engraved shields, spear throwers, sacred boards, and other objects from central, west, and south Australia. They are unsurpassed anywhere in their elegance and sensuous control of texture.

If the stylizations of aboriginal art are impressive, so is the extraordinary naturalism shown in A. R. Willcox's *The Rock Art of South Africa.* The artists who executed the paintings and petroglyphs had an astonishing ability to record natural beauty—particularly that of animals—with the utmost economy. It is also fascinating to realize the tiny scale of many of the paintings. Most are only a few inches long, and many are reproduced excellently, in color and black-and-white photographs. Mr. Willcox writes in an amiably relaxed style, perhaps deceptively so, for at the end he condenses into a relatively short text an impressive body of information about the Bushmen, their culture, history, techniques, styles, and the archeology of the region they inhabit. In the least contentious manner possible, he refutes other authorities, particularly on the score of the age of the art. Unlike the late Abbé Breuil, he does not believe the existing works cover a time range of more than 1,500 years, although he does believe that their ultimate ancestors are to be found in the European Paleolithic.

The natives of the Huon Peninsula in northeast New Guinea, where Schmitz gathered the material for his book, *Wantoat*, are not among the most creative of Papuans, nor is their religious art the most accomplished of the island, although it may well be among the most spectacular. Its very substance runs counter to the ideas of Western art that have been generally accepted until recently. The large paintings, life-size figures, and huge dance costumes are made almost entirely from perishable materials. Their meaning becomes more comprehensible if we use the analogies that Schmitz suggests, of "procession" and "show-altar," rather than "art-exhibition." We would not get the essence of the art without the help he provides.

In our culture, art is a source of aesthetic pleasure and a commodity. In the Huon Peninsula it may be both these things, but at the same time its existence is conditioned by ecology, social structure, and myth. Their interaction is what Schmitz sets out to disentangle, using admirable dexterity in the employment of relevant material. One could wish, incidentally, that he had given us more; his accounts of ceremonies are brilliant, but not complete. He shows himself an efficient functionalist who has no hesitation about using his data to reconstruct history and specializes in doing so.

According to Schmitz, this area shows the signs of two quite separate cultures. They are differentiated particularly by their myths of origins, which are expressed, rather than re-enacted, in the important ceremonials. Here then is an additional line of research which has not been much pursued before—the history of a primitive art within its own society. It is a promising one, and it speaks well for the proposed series, "Art in Its Context." As the first book in this series, *Wantoat* is a stimulus to our further understanding of primitive art.

*Mr. Newton is Curator of The Museum of Primitive Art, New York City, and has written "Art of the Massim Area, New Guinea," as well as other books on art.*

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BUDONGO: AN AFRICAN FOREST AND ITS CHIMPANZEES, by Vernon Reynolds. *Natural History Press, $4.95; 253 pp., illus.*

PRIMATE watching (excluding, perhaps, the observation of humans) will probably never overtake bird watching as an outdoor sport, because the parts of the earth inhabited by most of the people are not inhabited by other primates. This latter fact is unfortunate. The popularity of monkeys and apes in zoos attests to their intrinsic interest, and their observation in the wild, although difficult at times, is even more interesting. Readers of NATURAL HISTORY (January, 1964) had a preview of Vernon Reynolds' fascinating studies of chimpanzees in his article, "The 'Man of the Woods.' " Reynolds' book, which is an expansion of the article, is more than the story of the chimpanzees, for the reader sees the forest itself as a living, changing thing. He meets python, duiker, hornbill, and the goliath beetle, and he feels the cold, soaking afternoon rain and the piercing, itching bites of insects. Independence comes to Uganda, and the life of the people and of the forest goes on, not much differently, but not quite the same, either.

Analysis of legend often reveals our ignorance of an animal. George Schaller's recent studies, for example, have replaced the legend of uncontrolled gorilla ferocity with the fact that this huge and magnificent ape is usually

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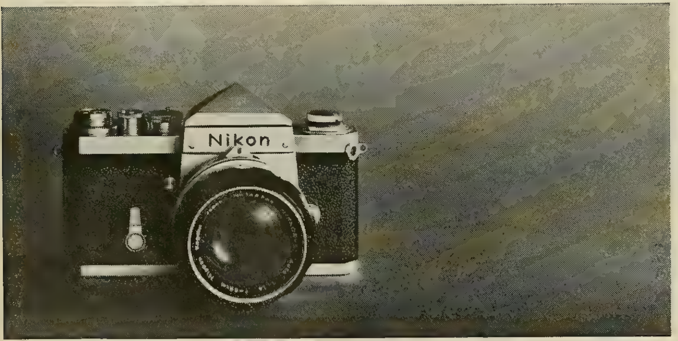

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quiet and restrained in movement—dignified would be a better word than fierce—and now Reynolds explains the legendary chimpanzee "drums" and "carnivals." They don't manufacture drums, but they do drum on the great buttressed roots of certain trees—and with resounding results. They do regularly congregate in large groups when fruiting trees provide a concentration of food, and the amount of activity and vocalization at such times does create a carnival-like atmosphere. Chimpanzees are more active than gorillas; they move around more, are much noisier, feed and usually build their nests in trees, rather than on the ground, and have more changeable social groups. Some of Reynolds' results have been published, and we hope more will appear, in scientific journals. Non-specialist readers will surely enjoy *Budongo.*

The book is well illustrated with maps, photographs, and drawings. There is a terminal list of only thirteen references and a helpful glossary of Latin names for most species of plants and animals referred to in the text by vernacular names. There is no index.

The Budongo forest obviously impressed Vernon Reynolds, and the book *Budongo* conveys his feelings as well as his observations as a naturalist.

SYDNEY ANDERSON
*The American Museum*

THE DEEP AND THE PAST, by David B. Ericson and Goesta Wollin. *Alfred A. Knopf, $6.95; 292 pp., illus.*

A PRIMARY concern for any scientist who attempts to convey the nature of his work to persons less knowledgeable or less involved is to relate results to broader perspectives. Re-creating the events of research may be of intrinsic interest but, unless both its conduct and results are of dramatic impact, it is not likely to catch the fancy of the reader.

In *The Deep and the Past,* David Ericson and Goesta Wollin have succeeded in presenting an experiment and its results (confirmation and acceptance of the results are still to come) in a definitive manner. They have related the experiment to broader areas of science, especially those of interest to the lay reader and, at the same time, they have illuminated the facts by accenting some of the romance involved. The experiment they have described necessitated the examination of hundreds of cores of sediments that had been taken from the floor of the sea (NATURAL HISTORY, February, 1963). The information extracted from these cores has ultimately resulted in the conception of a new scale of time for the Pleistocene Epoch (ice ages). Much of the book is devoted to an explanation of how this time framework is significant to the evolution of man and how it aids us in better understanding the sequence of events that occurred during the evolution.

Ericson and Wollin have developed the thesis that the beginning of the Pleistocene Epoch can be defined by a combination of faunal changes and extinctions among foraminifera and other groups of microscopic organisms. Having established an initial date (a necessarily arbitrary one) for the ice ages, the writers were able to correlate the faunal changes observed in long, deep-sea cores with climatic (temperature) changes indicated by evidences of glaciation on the land. The best indicator for faunal changes seemed to be the direction in which the foraminifers *Globorotalia truncatulinoides* and *Globigerina pachyderma* coil; this reverses with changes in temperature (in colder waters the former coils to the right; the latter coils to the left). The authors are at their best in describing the task of developing the recognition of this phenomenon, the cause of which is still unknown, and in applying this knowledge to the correlation of core samples. Careful examination of hundreds of cores, precise recording of observed data, and painstaking attention to detail were all factors in the development of methodology for correlation. Drawing on their combined information they were able to assemble a more or less complete sedimentary column for the Pleistocene from the deep-sea cores. Having demonstrated that the Pleistocene is marked by events sufficiently distinctive and widespread to be worthy of notice, Ericson and Wollin related these events—which might seem to the layman to be of limited significance—to the chronology of the evolution of man. By using carbon 14 measurements of the age of core sections and by cross correlation to cultural developments also dated by isotope methods, the developmental stages were placed in an absolute time framework. The effect of these researches upon the evolutionary chronology of man is to stretch it out and to lengthen the earlier periods of man's development.

The authors, by creating a readable account, have made a real contribution to informative and descriptive science literature. It is unfortunate that a little more effort was not expended to insure that the entire book was a truly first-class edition. The text is good and evenly edited, which is conducive to reading straight through or in long stretches. The black-and-white line cuts and correlation diagrams are intelligible. The photographs, however, are notably unspectacular and somewhat antiquated for this fast-moving field of marine geology. It is also regrettable that the few episodes that describe coring at sea are almost afterthoughts and have little continuity with the rest of the text.

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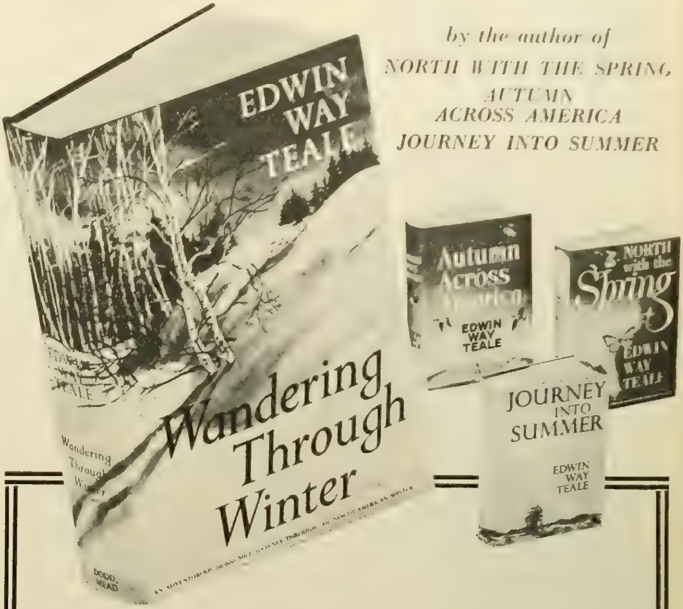

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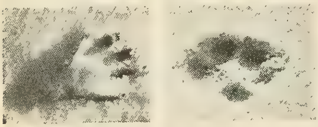

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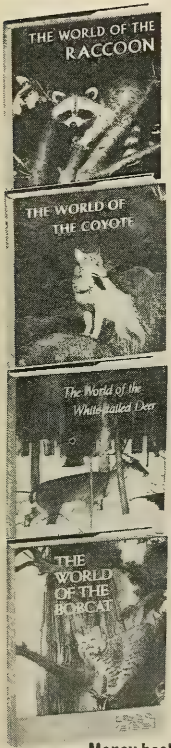

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Perhaps the most serious criticism that can be leveled against the book is that the authors have not offered their readers alternatives. Hypotheses and conclusions reached by other scientists are mentioned and, where appropriate, are discussed in some detail. Little attention is given, however, to the two major points upon which the authors' work has been attacked in the published scientific literature—the significance of the coiling changes of the foraminifera as opposed to other lines of evidence, and the criteria upon which the authors have defined the base of the Pleistocene.

These are minor complaints about a book that has admirably brought to life an important phase of earth science, which deserves publicity for its applications to practical and historical matters.

Donald Squires
*Smithsonian Institution*

Tall Trees and Far Horizons, by Virginia S. Eifert. *Dodd, Mead & Co., $5.00; 301 pp., illus.*

All of us who deal with plants professionally or for pleasure have become so accustomed to seeing abbreviations after the scientific names of plants that we pay them little attention. We may know that *Pisum sativum* L. is the garden-pea and that the authority for the name—the L—stands for Linnaeus. Except to the expert, most of the other authority abbreviations are almost meaningless. We know, of course, that they refer to names of people, and that is all. Consider, however, what this abbreviation represents. It usually means that a person went into a little-explored part of the world, collected the plants at considerable cost in time, energy, and money (not to mention discomfort), determined by comparative examination that the plant was sufficiently distinctive to be a representative of a new species, named it appropriately, and prepared a diagnosis of these special characteristics. Then, to indicate who first did this job, the person appended his (or her) name.

Thus, the designation takes on a new meaning, and one can begin to think of the authority as a person. The biographies of some of the early botanists in America form the subject of Mrs. Eifert's excellent volume. There was, for example, Thomas Harriot, who introduced Sir Walter Raleigh to tobacco and who, with John White, grandfather of Virginia Dare, presented the first floral description of the eastern seaboard to an intensely interested England. John Bartram, a self-educated botanist, virtually abandoned his farm in the Schuylkill Valley to travel and collect through the Appalachians, the Mohawk Valley, the still-wild Ontario region, and even into Florida—this at the time of the Indian wars, the Revolution, and the War of

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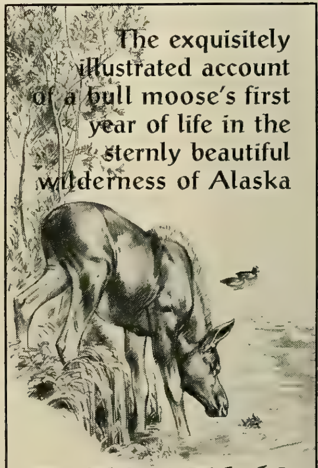

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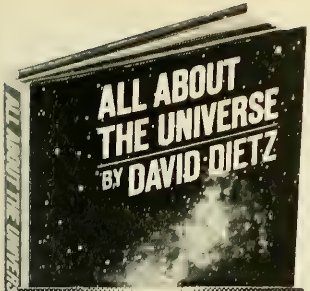

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1812! Jane Colden, daughter of a wealthy upper New York planter; Peter Kalm, a Swedish clergyman whose name is given to the incomparable mountain laurel; André Michaux, the French botanist who was a spy against, and explorer for, the United States; David Douglas, John Muir, and others are discussed with verve and an intelligent appreciation for their roles in exploration, taxonomy, and the country's life.

It is true that there are more detailed biographies of many of these early plant explorers and, indeed, most require a full volume to do them justice. It is equally true that none of these other books can be read with more enjoyment. I hope that Mrs. Eifert had as much fun writing this book as I had in reading it.

Richard M. Klein
*N. Y. Botanical Garden*

The Birds of Colombia, by R. Meyer de Schauensee. *Livingston Publishing Co., $10.00; 427 pp., illus.*

The importance of this book may well lie in its descriptions of the Andean–Amazonian bird fauna, the richest galaxy of avian species in the world. Information on these particular Colombian birds has never before been available in English, and it is extremely valuable, for it furnishes a collection of fundamental data that may be comparable only to the so-called Bogotá trade skins of the 1800's from which early ornithologists acquired their first knowledge of the existence of numerous Neotropical species. Thus, *The Birds of Colombia* has the effect of unlocking museum trays and exhibiting them to English-speaking countries.

On the other hand, it contains little ecological or behavioral information, nor does it fully describe other aspects that would be of special interest to an ornithologist—color of iris, for instance.

Happily, the author's word pictures receive assistance from eleven lovely color plates by Earl L. Poole, and from black-and-white drawings by Poole and George Miksch Sutton. In all, 344 species are illustrated.

A number of semitechnical features also contribute to the worth of the volume: a short history of Colombian ornithology; keys to the families; tables that compare the number of Colombian species within each family to the numbers found elsewhere; declarations defining the known distribution in Colombia of each race; and several maps—the best showing the high occurrence of Colombian birds in adjacent countries (regrettably, on the back of the dust jacket).

The collector in the field really has cause to praise this work. Heretofore, most ornithologists, when preparing to enter the Neotropics, have had to compose their own inadequate field manuals, keys, and slapdash sketches in an

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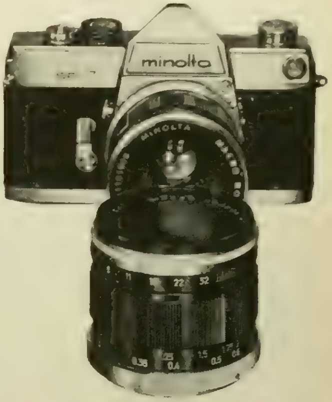

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attempt to cope with the abundance of little-known species belonging to difficult groups, such as the ant birds and flycatchers. Mr. de Schauensee has largely eliminated that necessity. I expect he also has signaled the beginning of a new, expanding ornithological era in South America. Having provided his fellow scientists with accurate means of identifying the great majority of their specimens on the collecting grounds, where the ripest conditions exist for determining and testing field identification techniques, he has quickened the process by which knowledge of the species of this area can be accumulated and documented. Authors of future books on Neotropical birds, in disseminating this new data, will no doubt owe Mr. de Schauensee an enormous debt.

William G. George
*Southern Illinois University*

### The Zambesi Doctors: David Livingstone's Letters to John Kirk, 1858-1872, edited by R. Foskett. *Aldine Publishing Co., $4.75; 187 pp., illus.*

To any but the most zealous devotee of African exploration this book might prove tedious, for the letters are presented with a minimum of editorial comment, and almost every one contains some tantalizingly obscure reference, leaving the reader mildly frustrated. The time gaps between many of the letters further prevent the collection from presenting a cohesive account of the life and travels of either Livingstone or Kirk.

Nonetheless, the end result is effective, for the actual explorations of these men were, in themselves, far from neat and orderly, being subject to a multitude of unpredictable disasters—minor and major. What does emerge from the letters is something of the character of each of these two great men, of the relationship of respect and trust between them, and of their mutual respect for their fellow humans. Insignificant details that never find their way into the more popular biographies and travel accounts appear strangely prominent, and despite the fragmentary nature of the letters they bring a feeling of intimacy that well repays their reading.

Colin M. Turnbull
*The American Museum*

### The Inside Passage, by Anthony Bailey. *The Macmillan Co., $7.50; 209 pp., illus.*

This volume carries the usual warning that "no part of this book may be reproduced . . . without permission." Here, it is superfluous. Any temptation toward piracy could be restrained.

This is an account of a trip through the alluring intracoastal waterway, which follows a sheltered course from New York City to the tip of Florida. Cruising "The Ditch" would seem to be the ideal opportunity to produce a joyous bit of slow-motion vagrancy literature of the Robert Louis Stevenson sort.

Alfred North Whitehead remarked that it is more important that a proposition be interesting than that it be true. The author's fidelity to facts is beyond question, but this seems to be a kind of diary with the dullness expanded and the spontaneity deleted.

Perhaps the fact that some parts of the book appeared in the *New Yorker* is significant. Here is the tired approach and the yawning condescension to everybody and everything. Some of the illustrations, such as those captioned "Meeting Street, Charleston," and "Savannah," are almost phenomenally atypical.

Freeman Tilden
*Author and Conservationist*

### Roadless Area, by Paul Brooks. *Alfred A. Knopf, $4.95; 259 pp., illus.*

Public interest in the preservation of wilderness, no matter where found, has mounted dramatically in the past few years. This is partly because of activities of various societies (including those listed by Mr. Brooks in an appendix to his book). For the most part, however, it is traceable to an awareness in the general public that it is in danger of being caught short—caught short of wilderness in America, in Africa, or wherever. In the United States, this has resulted in legislative or administrative action to preserve and protect what we have left.

There are few who contest the importance of these efforts, although some of them are undermined and discredited by the sometimes hysterical extremism of their most vigorous proponents. In approaching the problem of wilderness preservation, Mr. Brooks strikes a reasonable balance. I think his selection of a title, *Roadless Area*, is inadequate to suggest either the idea of wilderness on the one hand, or what one might expect to find in this book on the other. The wilderness is not necessarily without roads (the author and his wife do a good deal of jeeping), and much of the book has to do with practical observations on how to camp out almost anywhere, whether you travel by foot, by canoe, jeep, or horseback.

This is a well-written book, easy and pleasant to read. The impact of the author's plea for the preservation of wilderness is softly sensible. The nature notes taken by Paul Brooks and his wife as they move happily from one place to another make beguiling fodder for those of us less able to move about.

Pieter Fosburgh
*Author and Editor*

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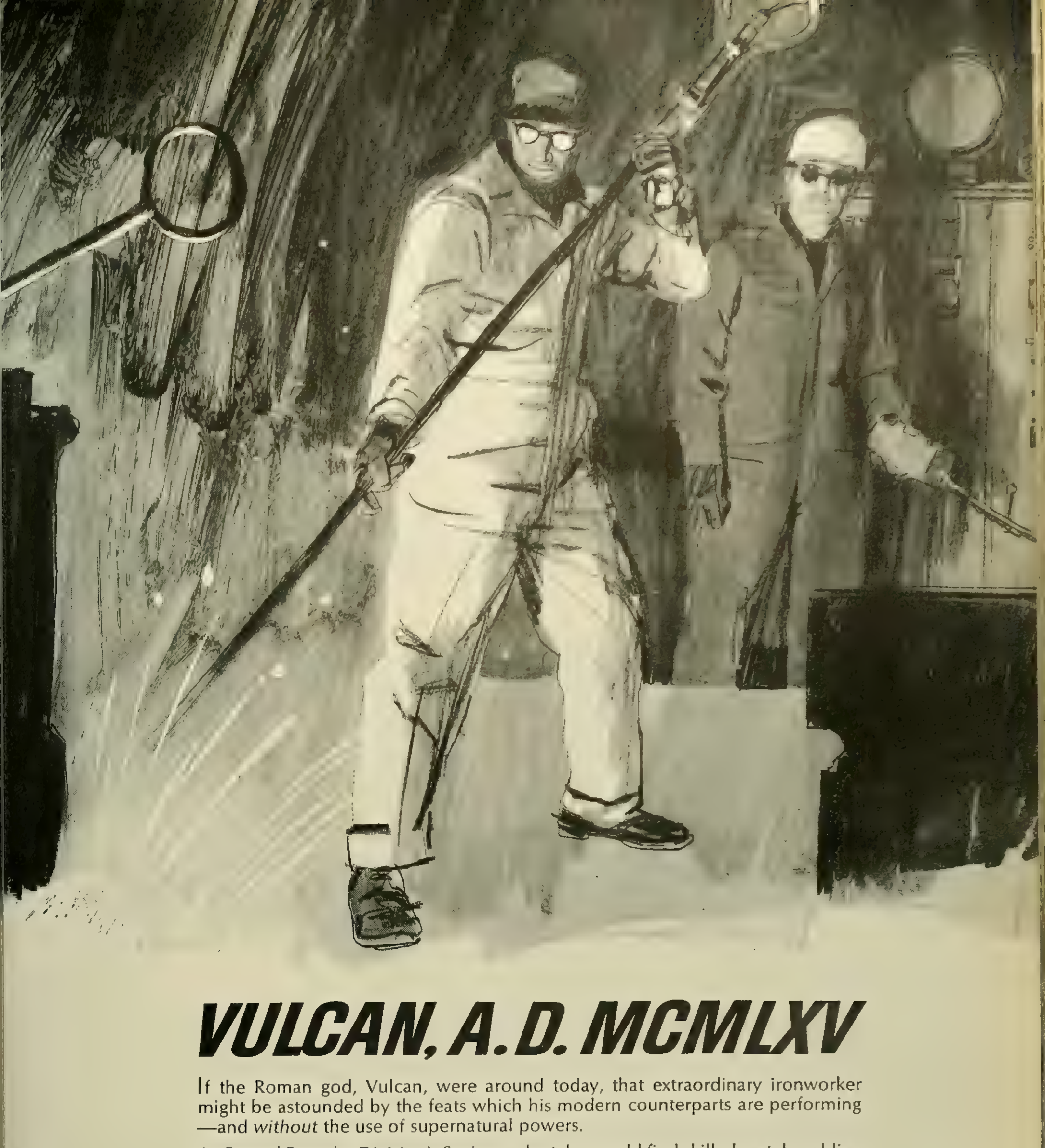

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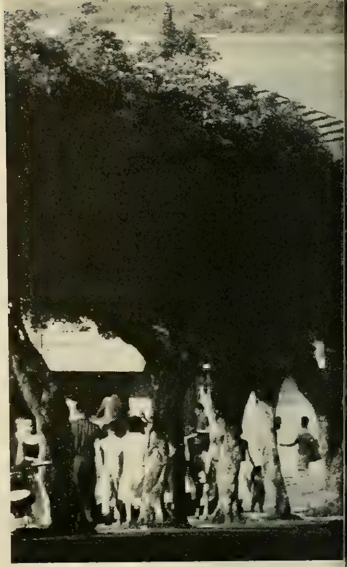
# The Floating Community of Amazonas



## Ancient city of Manaus is rich in history

By Fernando Dias de Avila-Pires

NEAR this fortress there is a small Indian town, where live also several whites. It is situated on the east bank of the [Negro] river, on a dry and elevated spot, although uneven here and there. . . ." (Description of Manaus by Governor General Ribeiro Sampaio, in 1774.)

In the middle of the Amazon Basin, one thousand miles from the Atlantic Ocean and three degrees below the Equator, lies a seaport. Its name comes from one of the four native tribes that roamed the lower Rio Negro forests—the Manáos warriors. Its name also reminds us of a legend about cities of gold, spread in Europe by Francisco de Orellana, who accompanied Pizarro in the conquest of Peru. He described a combat (in which he lost most of his men) fought against women warriors to whom he gave the mythological name of Amazonas.

In the local folklore these women are known as Icamiabas, and live under the protection of Iaci, the moon. Legend said they hunted and fought with bow and arrow and had their right breasts burned out in order best to handle that weapon. Once every year they were visited by the men of the Guaycari tribe, who lived across the river. Their children were raised separately, the girls by the Icamiabas and the boys by the Guaycari. This piece of folklore has undergone many changes through the years.

In 1660 the Portuguese built a fortress on the left bank of the Rio Negro, not far from the place where its inky-black waters join the muddy Rio Solimões, which below this point is known as the Amazon. This fort of São José do Rio Negro was intended as a checkpoint for travelers and traders coming from Mariuá (today, Barcelos), a settlement a long way upriver. It was also a stronghold against the Spaniards who dominated the Orinoco Basin and were trying to push east and south, taking the Castilian flag as far as the Portuguese allowed. A small trade in cacao, cotton, turtle oil for house and street lamps, and a few other odds and ends was maintained between Mariuá and Santa Maria de Belém do Grão Pará—the Belém of today—then the capital of an area one-third the size of Europe.

The fort soon became the center of a new settlement. Indians from the four tribes that inhabited the lower Negro region—the Manáos, Baré, Baniba, and Passé—were attracted there by a Jesuit mission. The village was officially known as Villa da Barra, or Barra do Rio Negro. When, in 1757, the community of São José do Rio Negro became part of the Province of Grão Pará, Mariuá was chosen to be the capital. From 1791 until 1799, the capital was Barra do Rio Negro (or simply, Barra), because of its strategic situation. In 1799, for political reasons, Mariuá again became the seat of government, and remained so until 1809, when Barra once more succeeded Mariuá as the capital.

In 1850, the Grão Pará was divided into two provinces, Pará and Amazonas. Barra (named Manáos in 1856) was made the capital of Amazonas, the larger province. The present spelling, Manaus, was adopted in 1939.

The city is located ten miles from the confluence of the Amazon and Negro rivers, at about the same longitude as the easternmost tip of Nova Scotia. It rises only 120 feet above sea level and is the center of an immense Cenozoic sedimentary basin. Of the old fortress, there are no remains. In 1850, Alfred R. Wallace found only the ruins of its stone walls.

THE climate of the Manaus region has been both praised and damned by foreign travelers from temperate lands. In the lower Rio Negro there are two marked seasons: one lasts from January to June—the winter—when the heavy rains (149 days) cause the temperature to drop, especially in the evenings (the lowest ever registered was 63.7° F.); the other—the summer—lasts from July until December. This is the dry season, and the mercury climbs steadily. There is an average of only 22 rainy days in this period. The maximum recorded temperature is 100° F., but a 365-day average of 85 per cent relative humidity is responsible for the depressive feeling one so often experi-

STREAMS and channels criss-crossing the river's left bank support the floating suburb, here seen from Manaus proper.

BUILT on rafts or on the tops of boats, palm-thatched houses ride on waterways known locally as *igarapés* and *paranás.*

**Principal** means of transportation is provided by deep, black water of Rio Negro, on which tiny craft and those of large tonnage are able to navigate.

**Maze** of boardwalks connects houses, shops, and restaurants of the suburb.

**Cooking** is not too basically different from ancestral Indian type. Turtles, fishes, wild fruits, and roots often are prepared with sauce of manioc juice.

ences in the area. The annual mean temperature is 82.4° F.

The agricultural possibilities of the Amazon Valley have also been a matter for dispute. Some naturalists, like Wallace, were too optimistic, while others have expressed their doubts concerning the value of the soil, once the forest is cleared off. The local populations are too impoverished to handle a problem of such magnitude, and most foreign enterprises have been wrecked by basic mistakes originating from the lack of knowledge of local conditions. In most areas the topsoil is only a thin layer that is rapidly washed out by rain and flood as soon as the forest is removed and the ground exposed. Leaching takes place, leading to the formation of a poor lateritic soil. The dry areas are poorer than the periodically flooded marginal lands, and the wide stretches of grasslands do not produce enough to justify hopes that the Amazon will become the world's storehouse—at least not while conventional agricultural methods are used.

Rain and water are ever-present and overwhelming in the Amazon—in the immense volume of its rivers and in the diluvial rains. They provide special conditions for the development of the area's remarkable flora and fauna and have even helped evolve a rich folklore. Tomlinson wrote in *The Sea and the Jungle,* "A journey across country is never made by the Brazilians. The only roads are the rivers. It is a rare traveller who goes through the forests, guided only by compass and his lore of the wilderness."

In 1928, G. H. H. Tate wrote in his logbook of The American Museum's Tyler-Duida Expedition: "Grande Hotel, 23-Aug.-28- *The Boa Vista Road:* Last Sunday we got a car and toured out to the limit of construction of this road. It is now just forty kilometers long, and has been under construction for goodness knows how many years. It cut right through the forest in its more distant part. Boa Vista is only 700 miles away and they build two kilometers a year. When will they get through?" They haven't yet.

Dozens of different types of craft crisscross the often turbulent waters of the Rio Negro: from the tiny, dugout-type *cascos* and *montarias,* whose paddlers crouch on the bow, to large commercial steamers. Small craft usually negotiate the side channels, avoiding the risks of being caught in the middle of the main channel by the *banzeiro*—the choppy waves caused by strong winds—that would endanger lives and cargo. Coming down from settlements upriver, or returning home, paddlers usually get a free tow from one of the powerful motorboats.

**Running water,** for travel and baths, cooking and laundry, is at the door.

Quasi-absence of roads in the Amazon did not prevent Manaus from becoming truly a city of gold in the first decade of the twentieth century. In 1850, it was a town of fewer than 6,000 people. Thirty years later the number of inhabitants was about the same. But in another ten years the population rose sharply to 50,000 because of the world's demand for rubber. The Amazon Valley maintained a monopoly on rubber until 1912.

Located in the center of distribution of the rubber tree, *Hevea brasiliensis,* Manaus exported 9,371 tons of the crude product in 1892 and 43,000 tons in 1912, all of which was extracted by an army of outsiders working under slave conditions. To illustrate the modification in the local economy, a few figures will suffice: in 1848 the total revenue of Amazonas

**Marketing** is a holiday. Pilots in the region paddle crouched in boat's bow.

Province was 300 *contos de reis,* while fifty years later, in 1897-98, the Theatro Amazonas, in Manaus, a copy of the Paris Opera House, signed an opera and drama company from Europe (with Sarah Bernhardt as star) and paid all expenses, plus 344 *contos de reis*! Several public offices were housed in large new buildings, and a tramway system was built. An upper class of *nouveaux riches* was formed, consisting primarily of traders and merchants who had started as river peddlers and ended up as store owners.

Between 1876 and 1910, Henry Wickham, H. W. Steed, and others took the seed of *Hevea* back to England for germination. There, in Kew Gardens, Surrey, the fragile shoots did not seem to thrive. Taken to Malaya and Ceylon the plants did well, and these original seeds taken out of Brazil became the ancestors of nearly all the rubber trees in the East Indies.

By 1913 Asia ranked even with the Amazon Valley in rubber production, and the crash was felt throughout the valley. Cheap labor and adequate management were factors favoring the Asian economy. In the Amazon, primitive methods and natural difficulties consumed both time and money.

The rich upper class, which had sent its linen to be laundered in Europe, had consumed lavish and expensive imports from France, and had impressed visitors by lighting cigars with bills of large denomination, saw its businesses vanish. The price of rubber went down, and the *seringais*—territories where the wild rubber trees grow—were abandoned little by little. The opera house was closed (it was repaired and reopened in 1961), and the outposts were deserted. Famine and misery ran through the valley, and the Manaus legend faded away.

But like the phoenix, the city was not dead. The seed of civilization had been planted and soon started to germinate like a pasture after fire. A trade of river products (fish, turtles, caiman skins, turtle eggs) and forest goods replaced the rubber. Today, Manaus is growing like any other city of the Brazilian interior, building its future on a sounder basis than a one-industry economy.

The city rises high above the flood-mark of the Negro (in 1909 the river rose 46.2 feet and in 1953 more than 30 feet) and is cut by small streams and channels, locally called *paranás* and *igarapés*. In those rivulets and in the main river, a unique suburb has spread out along the banks. Private houses, restaurants (with the best fish dishes you can find in the whole region), and small shops, all on floats, are connected by a maze of boardwalks and served by a natural system of running water, sewage disposal, and free transportation provided by the river. Some of the houses are built on rafts, some on top of craft of all sizes. Whoever is not happy with his neighbors can simply paddle his way to a new spot.

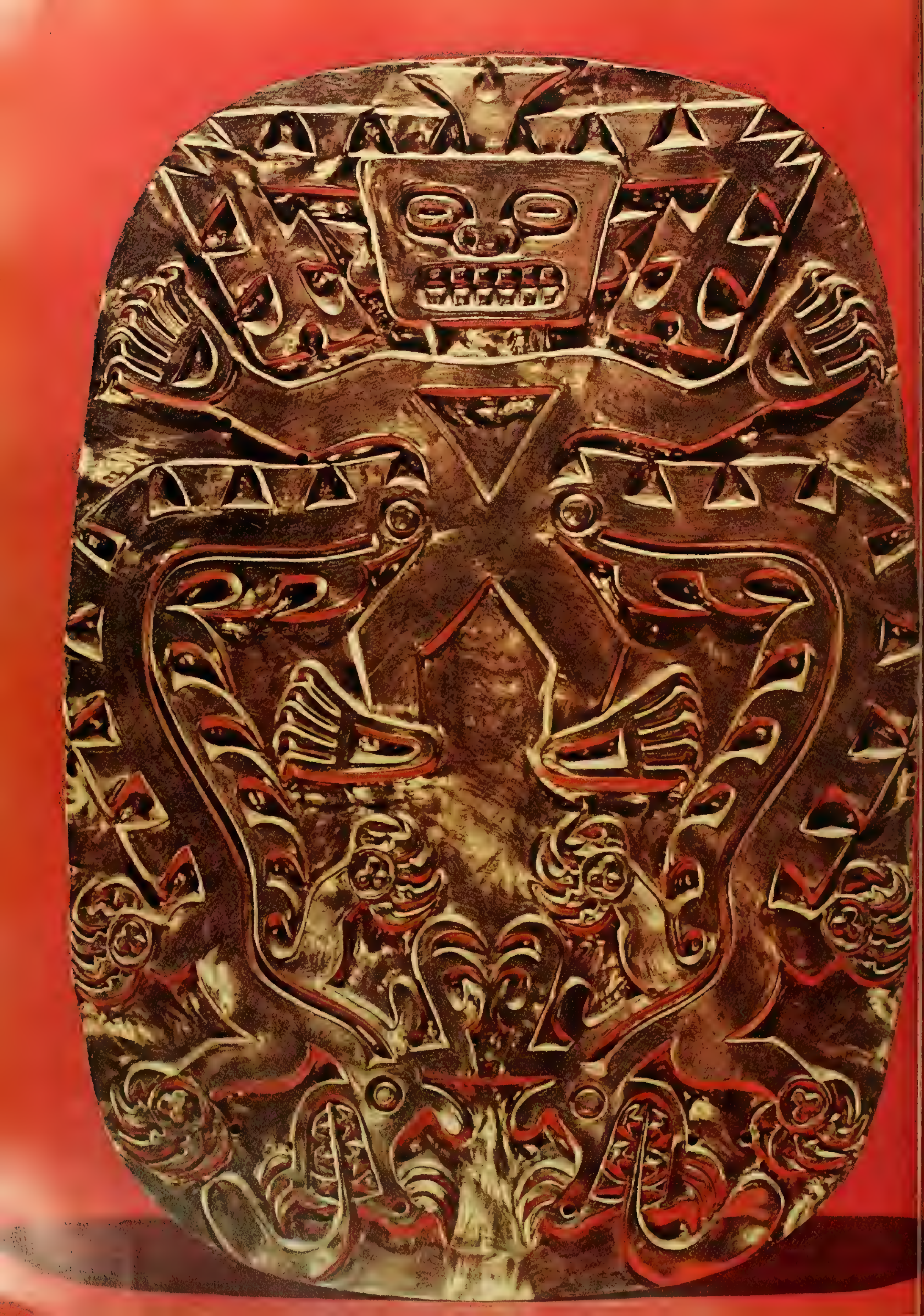
Peddlers, paddling small dugouts, earn a living as door-to-door salesmen. They sell fruits of the season, fish, refreshments, and anything else that can be carried in their small keels. Some of the houseboats have small gardens in which local plants grow in wooden boxes or empty kerosene cans.

Most of the men are in the fishing business, sailing day after day after the tambaqui (*Mylossoma duriventris*), curimbatá (*Prochilodus scrofa*), tucunaré (*Cichla temensis*), and other species of the richest fresh-water icthyological fauna of the world. If they are exceptionally lucky they can get either a big turtle or a pirarucu (*Arapaima gigas*), the largest of all fresh-water fish. The bony tongue of the latter is used to grind the fruit of the guarana (*Paullinia cupana* Kunth). These fruits, when dried, become very hard and, after being ground, are mixed with water to make a local soft drink that contains about six times more caffein than coffee.

After living four years in the Amazon and studying its natural history, A. R. Wallace wrote:

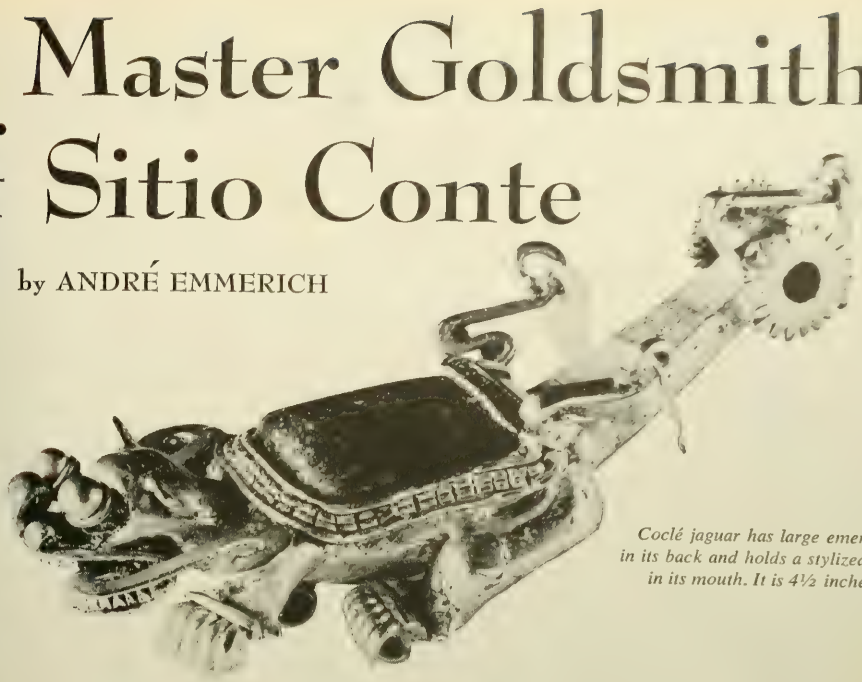
> "I would be an Indian here, and live content
> To fish, to hunt, and paddle my canoe
> And see my children grow like young wild fawns
> In health of body and peace of mind,
> Rich without wealth, and happy without gold."

**Outhouse** shares deck space on a ra
with plants in an assortment of holder



# Master Goldsmiths of Sitio Conte

### by ANDRÉ EMMERICH



*Coclé jaguar has large emerald set in its back and holds a stylized snake in its mouth. It is 4½ inches long.*

THE long, thin land bridge of Panama curves out toward the northwest from the main land mass of Colombia, only to swing back again in a southwesterly direction to form the Bay of Panama before turning northwestward once again to join the widening Central American land mass. The easternmost provinces of Panama, which lie between the Colombian border and the Panama Canal, are as yet little-known either generally or archeologically. No roads traverse this part of the country; no settlement larger than two thousand in population exists.

Just to the west of the Pacific entrance to the Panama Canal, inside the border of the Canal Zone, is the site of Venado Beach ("deer beach"). For many years this served as a target area for firing practice of the artillery stationed at nearby Fort Kobbe until, in the late 1940's, a bulldozer by chance brought to light an ancient Indian settlement fronting the beach. Burials by the hundreds were found, excavated at first through a great deal of unrecorded digging by soldiers from Fort Kobbe. In 1949 the Archaeological Society of Panama was formed by responsible amateur archeologists in the Canal Zone. They proceeded to keep a photographic record of the more important finds and conducted some careful, properly recorded excavations. A systematic, full-scale excavation was conducted by Harvard University's Peabody Museum in the winter of 1951.

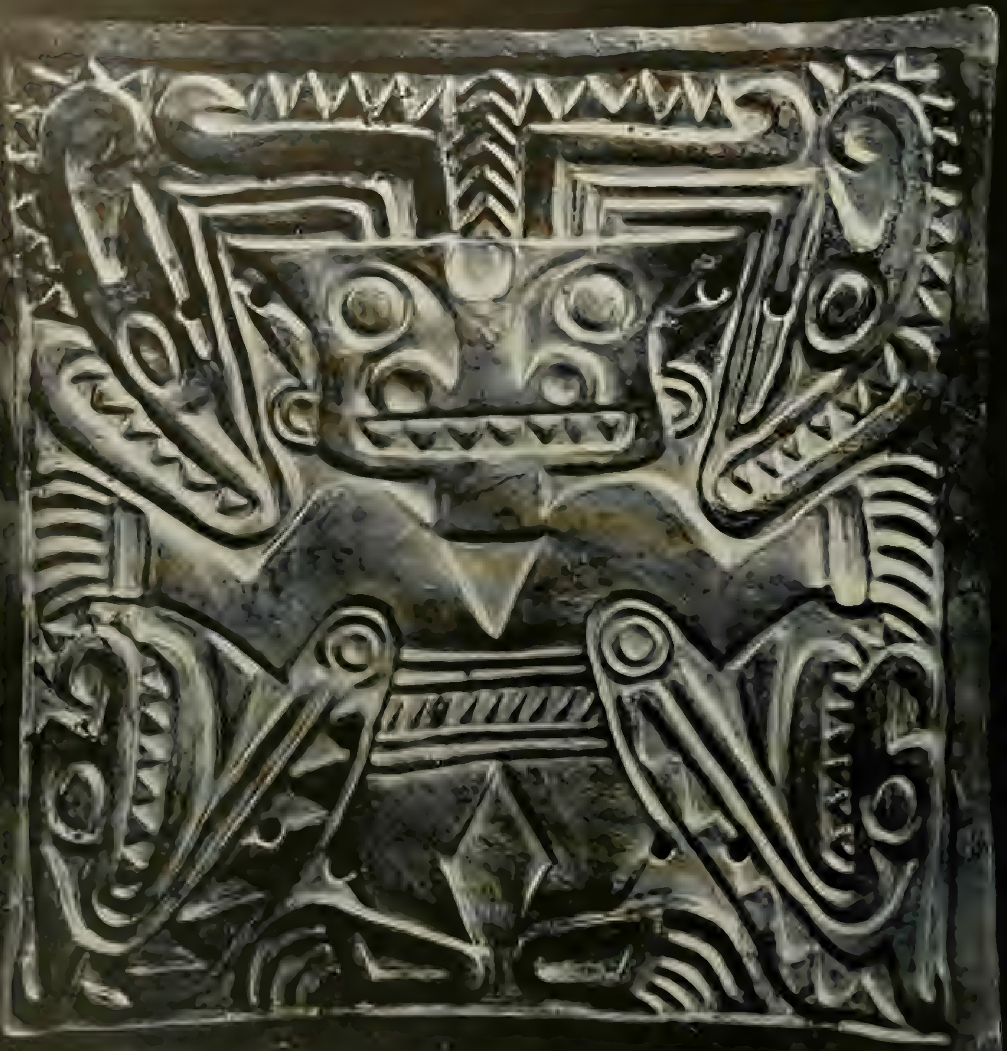
The objects found at Venado Beach indicate that the site was occupied by people who formed part of the same basic culture found somewhat farther to the west in Coclé Province and on the upper Azuero Peninsula along the Gulf of Parita. Some fine pottery was found at Venado Beach, but the apogee of aesthetic and technical achievement is represented by the superb gold jewelry that was interred in these graves.

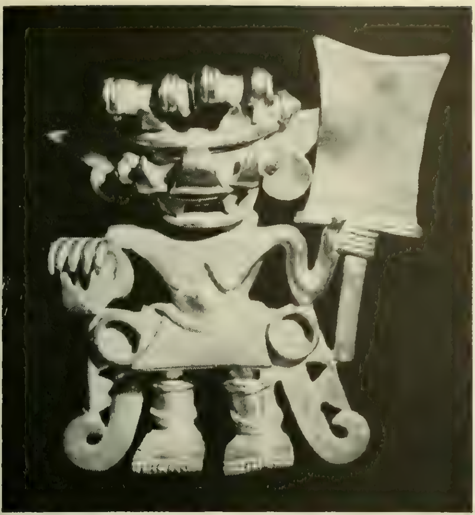
Two radiocarbon dates have been obtained at Venado Beach. Both are based on the black carbonized powder found in typical pottery urns containing infant burials. One test indicated an age of 1,000 years, placing the Venado Beach site in the tenth century A.D. The other test gave a reading of 1,750 years, suggesting that the site was already occupied and its culture flourishing in the third century. At the same time the early date of the second radiocarbon test may have represented an error. As Junius B. Bird has noted, it is to be expected on statistical grounds that in one out of three carbon 14 tests the correct date will actually fall outside the margins indicated by the reading.

THE most important discoveries of Coclé material to date were made at the famous Sitio Conte (the site on the Conte family property) near the town of Penonomé in the center of Coclé Province.

Samuel K. Lothrop has suggested that the burials found at Sitio Conte cover a period of several centuries. The early and middle phases correspond to the Venado Beach find, but the burials also cover a later, decadent period of declining workmanship, which is especially evident in the pottery. By the time of the Conquest the power and importance of the chieftains of the Sitio Conte-Penonomé area had been considerably lessened,

*Gold breastplate of repoussé design shows anthropomorphic, crested alligator god, a dominant religious concept.*

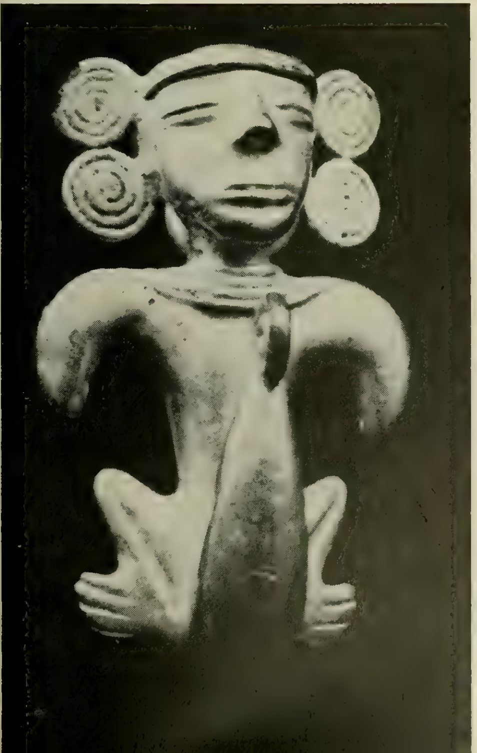




*Anthropomorphic deity is represented by a figurine of bat-headed human brandishing a large ritual battle-ax.*

*Square Coclé breastplate, at left, was discovered in the excavations near Parita River. It has reptilian motif.*

*Human effigy of gold, with animal's feet and tail, is example of Coclé skill in using process of hollow casting.*



and this is reflected in their poorer tomb furnishings. The center of power during the later period, judging by the records of the early conquistadors, had shifted to the west, to the areas around the town of Natá and along the Rio Parita. The river and the gulf into which it empties, as well as the principal town in the river valley, are all named Parita after the reigning paramount lord of the region at the time of the Conquest.

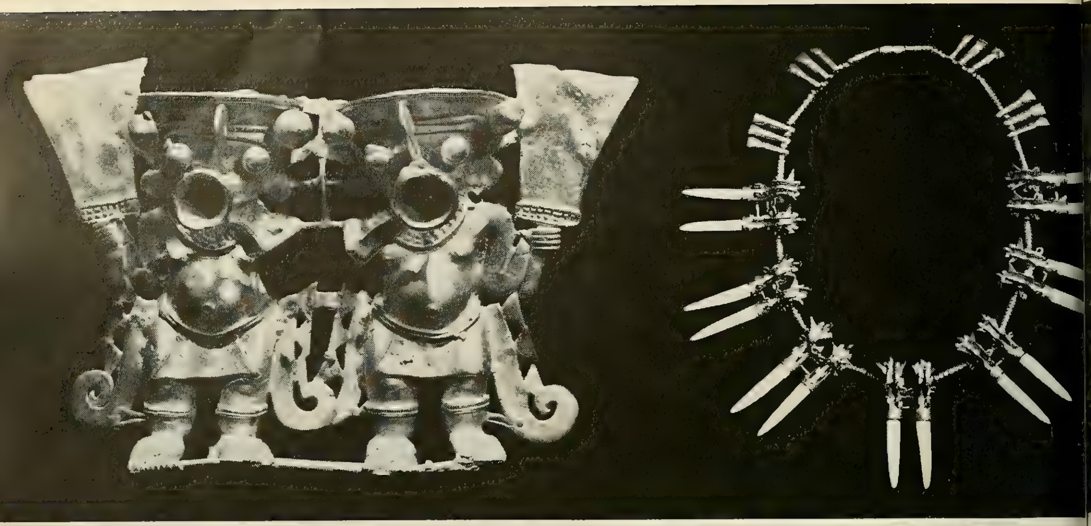
This powerful ruler attempted to dissuade the exploring, gold-hunting Spaniards from entering his domain in 1515 by offering them a bribe of a number of baskets full of gold jewelry, weighing between 420 and 525 pounds. The effect of the rich gift was the opposite of the desired one, for it only brought about a new determination of the Spaniards to raid these lands. Various expeditions against Parita failed, however, and it was not until 1519 that a raid finally succeeded, only to find Parita dead, lying in his house prepared for burial.

Within Parita's house were encountered the corpses of three chiefs, each of which had been dried by fire and then enveloped in cloth bundles of many layers and slung in straw hammocks. When the Spaniards tore off these outer wrappings, they beheld the body of Parita himself and of two other chiefs. Parita had been laid out for burial in his finest array. On his head was "a great basin of gold like a casque"; around his neck were four or five necklaces of gold; his arms and legs were encased in tubes of gold, and his chest and shoulders covered with plates and medals of gold; around his waist was a gold belt from which small gold bells were hung: to the astounded Spaniards it appeared as if he wore a coat of gold mail. At Parita's feet lay the body of a woman, at his head another, both adorned with many fine gold ornaments. They had presumably been killed to accompany their master into the hereafter.

Coclé gold figurines were traded over a wide area of ancient America. Many typical Coclé figurines were found in the Cenote at Chichén Itzá in northern Yucatán. The legs of what appears to have been a typical Coclé *tumbaga* (a gold-copper alloy) figure were found underneath a Classic Maya monument, Stela H, at the temple city of Copán near the Honduras-Guatemala border. The glyphs on the stela record that it was erected on the Mayan calendar 9.17.12.0.0., which, according to accepted correlation, falls in the year A.D. 782. Recently a group of Coclé pendants was found in northern Costa Rica together with typical Early Classic Maya incised slate mirror-back disks dating from the fifth century A.D.

The crested alligator is a major motif that runs through all of Coclé art, often in a highly stylized form that becomes a kind of iconographic shorthand. Judging by its frequent and widespread appearance in the art of Coclé and also to the west in Veraguas, Chiriquí, and the Diquís region, it seems almost certain that the design represents an all-pervasive deity or religious concept.

The embossed breastplates of Coclé are among the most beautiful objects produced by this culture and the finest accomplishments achieved with the *repoussé* technique anywhere in ancient America since Chavín times (*at far left and page 18*). These were first hammered to size out of soft, relatively pure gold and then worked with an awl over a yielding surface of leather or pitch,



and when they are encountered in excavations usually have the mat patina associated with archeological gold objects. The early Spanish accounts, however, repeatedly refer to breastplates as "mirrors," indicating that originally they must have been burnished to a high gloss, catching and reflecting as much light as possible.

A spectacular object decorated in the same style as the breastplates is a gold helmet excavated by the Peabody Museum. As on the breastplate, an intricate design fills every available inch of space with a rhythmically flowing, admirably handled composition of great strength and sculptural force, which is maintained notwithstanding the complicated, symbol-laden design. The balanced, sinuous flow of form is of a quality only rarely encountered in any culture and never surpassed in ancient American metallurgy.

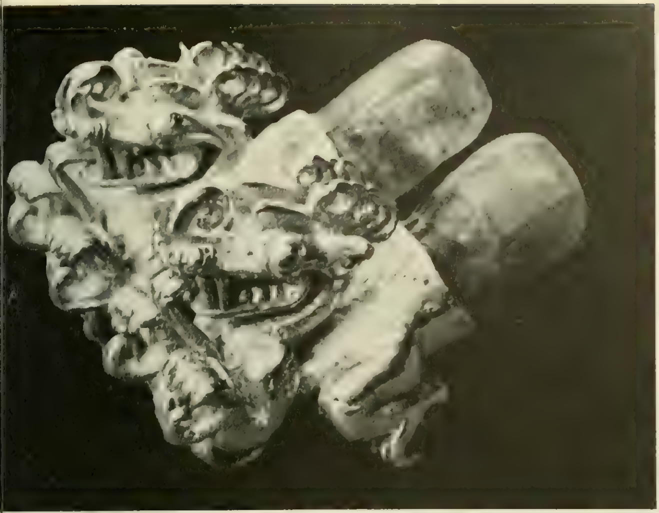
Another specialty of the goldsmiths of Coclé was the setting of gold jewelry with precious and striking materials including emeralds, quartz, jasper, opals, green serpentine, tawny agate, mother-of-pearl, bone, and whaletooth ivory. Two techniques were used. The simpler and presumably older one called for an object to be carved out of a tooth, wood, or copal that then was partly covered with hammered gold sheathing. The more advanced and difficult method involved casting an ornament as a setting for a specific jewel, such as an emerald or a quartz crystal, or utilizing precast settings of this type for inserts that could be carved to fit, such as whaletooth ivory.

THREE emeralds in settings were found at the Sitio Conte, the largest and most splendid of which is shown on page 19. This emerald measures 27.5 by 30 mm. (approximately 1.08 by 1.18 inches) and is set in a gold pendant 4½ inches long, representing a jaguar holding what is probably a stylized snake in its mouth. The jaguar is suspended from a necklace through the loops created by the curved claws of the animal's front paws. The tongue of the jaguar was soldered into place, but the remainder of the animal was cast in one piece except for the loose bangles.

The two other emeralds and a white quartz crystal were held in another type of gold setting that clasped only the upper section of the stone and left the lower portion entirely free. The gold settings of the two emerald pendants represent complicated mythical animals, while the setting of the quartz is in the form of an insect. A similar pendant is reproduced on page 23, top.

The goldsmiths of Coclé were among the few in ancient America sufficiently skilled to make hollow castings in the round over clay and charcoal cores. A specialty of the goldsmiths of Venado Beach was a distinct type of cast-filigree effigy pendant that seems to be related to the filigree nose rings and animal figures of the Sinú culture (*see page 24*). These were painstakingly made by placing thin wax threads over a core of clay and charcoal, which was removed after casting. The wirelike scrolls had to be arranged by the craftsmen so as to create a realistic animal figure, as well as a pleasing symmetrical pattern in themselves. At the same time the wax threads had to be placed so that the molten metal would flow without hindrance through each of the tiny channels formed by the wax threads. The general form of the typical, small human effigy figurines produced by this method is strongly reminiscent of the large figurines of the Quimbaya, or late Chibcha-Muisca, culture, although executed on a much smaller scale (*see page 21*). They are often represented holding rattles or ceremonial batons in both hands. Clothing is rarely shown other than elaborate headdresses and a type of wide, beaded collar with triangular and chevron designs similar to those still made by the Guaymí Indians of Panama. The collars are thought to have been symbols of authority.

The hollow-cast human figurines are almost always finished completely in the round. To cover the rectangular gaps where the inner core was held in place during

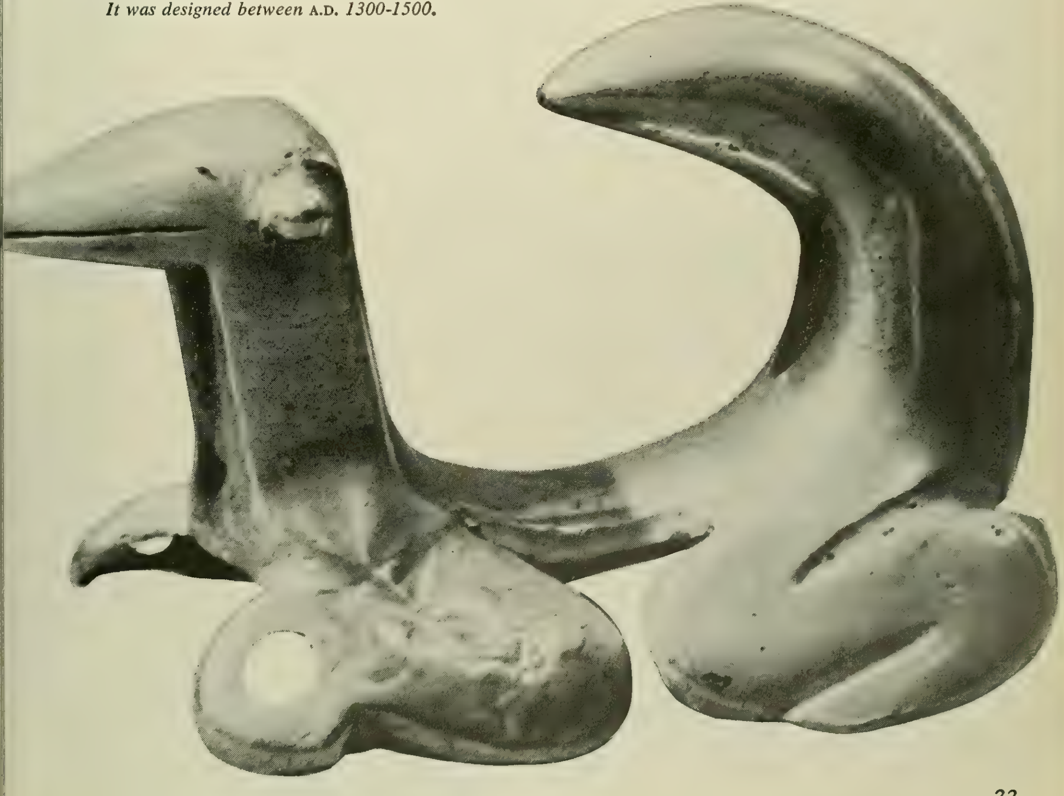


*Twin figures of gold, far left, blowing trumpets and holding ceremonial axes, are from upper Azuero Peninsula.*

*Necklace of carved whalebone set in gold pendants, center, employs the alligator motif. It was found in Parita.*

*Double jaguar drop with quartz inlays is an example of Coclé goldsmiths' art of combining rare metal and stones.*

*Unidentified beast, perhaps a lizard, was made to be worn as an ornament. It was designed between* A.D. *1300-1500.*



the casting process, small plaques were inserted and soldered into place. By contrast, animal figurines, especially the typical parrot and curly-tailed monkey effigies, are often hollow and open from the bottom where the large rectangular openings were left uncovered. A delightful variation is the animal pendant with as many as four animals lined up abreast, cast in a single flow of metal. The virtuoso playfulness and skill of the Coclé goldsmiths is demonstrated in the charming miniature animal pendants they cast.

Unique to Sitio Conte are elaborately detailed stylized frogs, which apparently were worn sideways as nose ornaments. Another ornamental form found only in Coclé consists of long ear rods of serpentine, sheathed top and bottom with gold, which were worn inserted through perforated ear lobes. They are as much as seven inches in length and must have touched the collar bone.

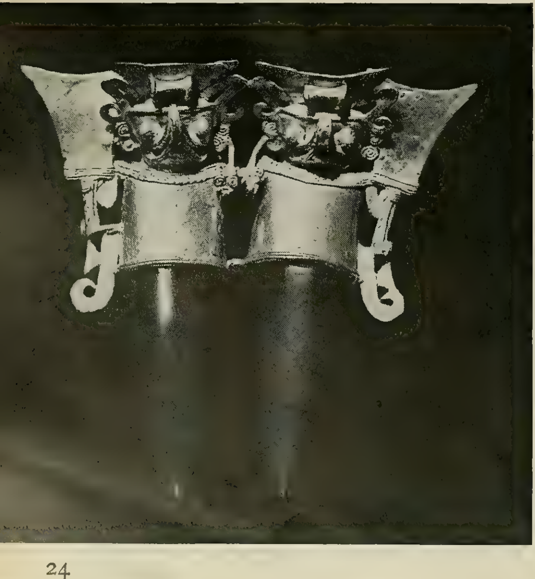
OTHER sheet gold specialties of the Coclé goldsmiths included bracelets in the form of tapered cuffs, sometimes decorated with embossed stylized designs. Hammered sheet gold was also used to make leggings, belts, and plain headbands. An unusual type of headdress crest also found at Sitio Conte consists of conical gold forms with embossed borders, which appear to have topped elaborate headdresses. Finger rings are rare in Coclé, but recently some superb examples were excavated.

Coclé jewels are often accompanied by long necklaces of cast-gold beads. Some have measured up to 9 feet 10 inches in length and numbered up to 1,200 virtually identical individually cast beads in a single strand. Many are made of extremely fine, thin gold that was cast over inner cores, which were intended to remain in place to support the eggshell-thin walls of the beads but which have disintegrated with time.

New finds keep turning up unexpected accomplishments of the Coclé goldsmiths. In 1963 a number of pendants were brought to light, each consisting of a pair of figurines that had been individually cast and then joined to their partners with a series of tie rods. In some instances the tie rods were apparently soldered into place, but others are held together by a system of hooks and loops that is unique in known examples of pre-Columbian metallurgy (*photograph, below left*).

Other discoveries document the spread and long continuity of the culture of Coclé. Elaborate burials with typical Coclé tomb furnishings have been excavated on the upper Azuero Peninsula and throughout the area whose geographical features are still named after the paramount chief Parita, whose interment was interrupted by the Spaniards. One such tomb, which is reported to have contained goldwork of typical, classical Coclé style, has yielded a radiocarbon date of 480 ± 75 years, thus placing it at *ca.* A.D. 1482, within the period immediately preceding the Spanish Conquest. If this date is upheld by future studies, it would appear that the Coclé goldsmiths continued to produce their masterful ornaments right up to the Conquest. The center of production, however, would appear to have shifted from the Sitio Conte area in central Coclé to the west toward the Azuero Peninsula.

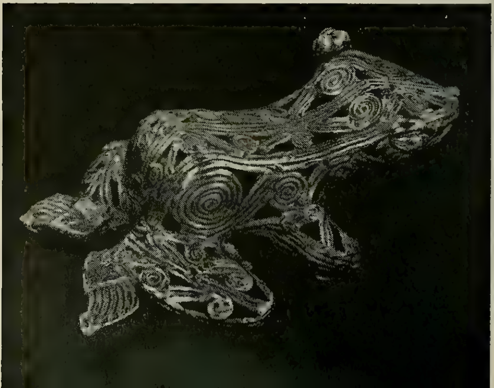
Little work has been done to chart the chronology of Coclé goldworking. Judging by the distribution of gold ornaments in the early period and late period graves at Sitio Conte, there is a remarkable consistency of style during a span extending over many centuries, and with much less apparent variation and development than is visible in the pottery that is found in the same tombs. The changes that have been noted are minor: N-shaped incisor teeth, ear spools, and filigree nose rings are found exclusively in early burials, while ear rods and solid metal nose rings belong to the late period. In the meantime, further discoveries continue to contribute hitherto unknown material that one day may shed additional light on the history of the Coclé style.



*Zoomorphic deities in the form of a double pendant, at left, hold symbolic axes, and are of gold and serpentine.*

*Designed with a twin mushroom-head ornament, cast-gold idol, right, holds a stylized mask in front of its nose.*

*Frog of hollow, openwork filigree is fine example of Coclé goldsmiths' mastery of complicated art of casting.*



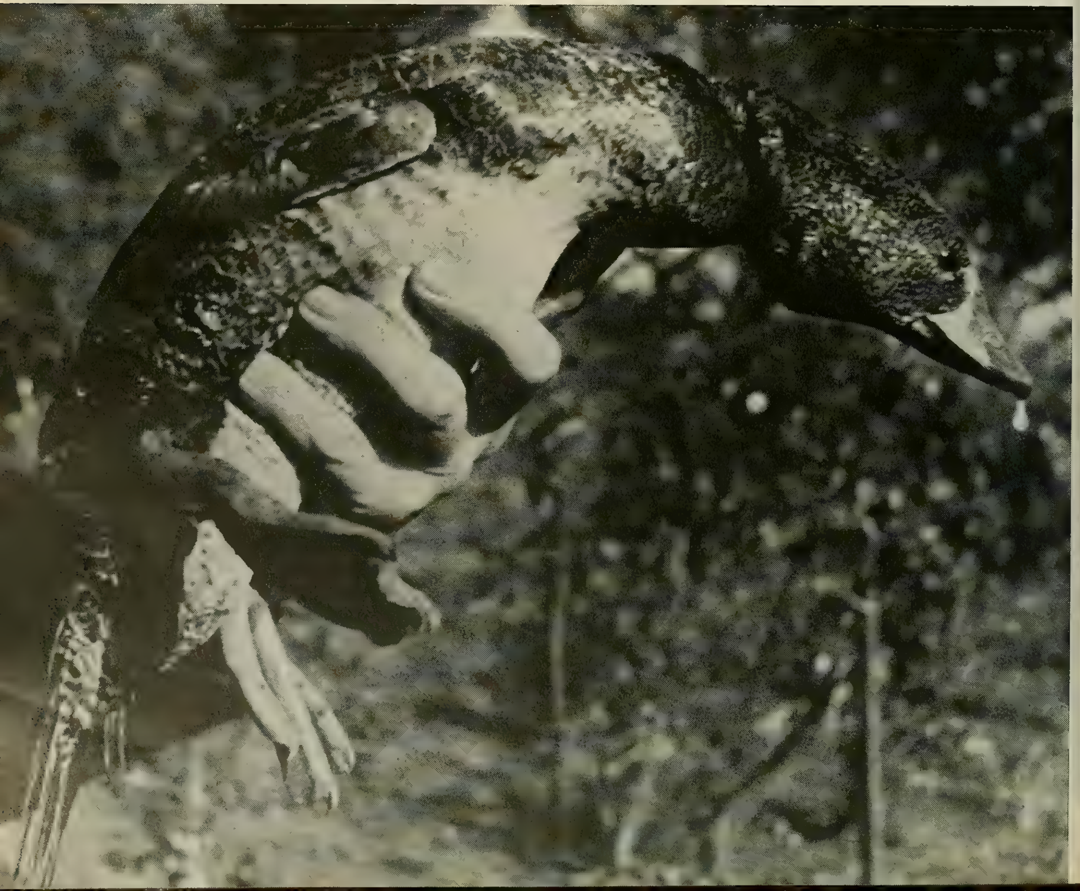
# The Elusive

## Unusual behavior makes species both

By Paul A. Johnsgard

If one were to try to choose the most remarkable duck in the world, serious consideration would have to be given the Australian Musk Duck (*Biziura lobata*) of the family Anatidae. Among its unusual features are the great dimorphism of the sexes (males weigh eight pounds or more and are about three feet from bill to tail; females weigh two to three pounds and measure about two feet), the leathery pendent lobe that is located on the lower mandible, the strong odor of musk that is prominent in males during the breeding season, and the remarkably large eggs (averaging one-half pound). To these facts it might also be added that comparatively few people have ever seen Musk Ducks fly, that males have a most unusual whistling call, and that the males' displays are so loud and conspicuous that they can be seen and heard for at least a half mile under favorable conditions. In spite of all these unusual characteristics, no comprehensive studies on the biology of this species exist. This is the more remarkable considering the abundance of the bird over the southern half of Australia. The Musk Duck is of relative unimportance as a game species, since both sexes are of a dull gray color and, as they rarely fly, make poor targets. Also, the birds have a tendency to inhabit weedy, overgrown marshes and to dive from sight at the first sign of danger. This behavior probably is the reason that relatively little has been written about them.

On reading the available literature on the Musk Duck, the paucity of definite information about it becomes apparent. For example, the origin of the musky odor has not been determined, although presumably it originates in the uropygial gland. Second, although the normal clutch of eggs is believed to number only two or three, some clutches of up to five or six have been reported, perhaps the result of several females' activities. Some writers suggest that the large males are essentially flightless, yet adult birds will suddenly appear on a lake in con-



# Musk Ducks

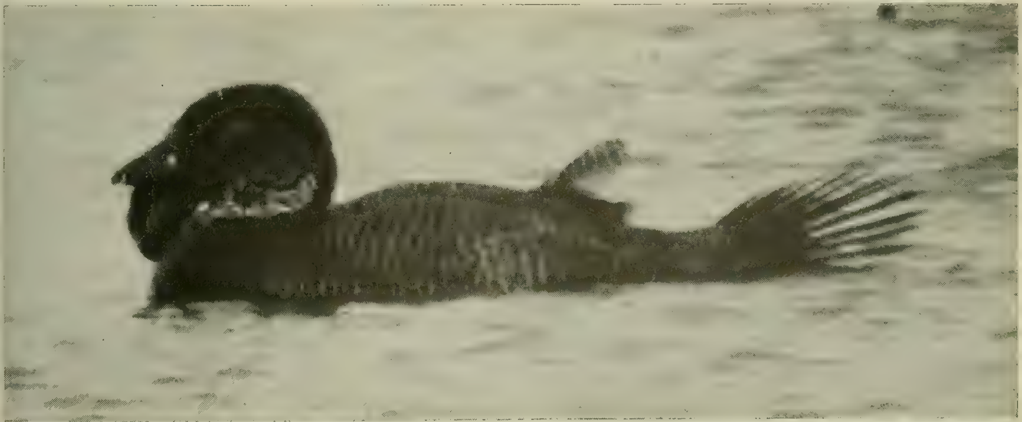
## conspicuous and difficult to observe

siderable numbers and disappear just as rapidly. Likewise, large numbers will arrive at coastal areas during the winter, foraging in the shallows on invertebrate life. No definite function can be readily attributed to the lobe, which is largest in old males and rudimentary in females, but as it is not hollow it cannot serve for food storage as does a pelican's pouch.

If the lobe, the sexual dimorphism, and the musky odor are ignored, the remaining features of the species agree well with those of the typical stiff-tailed ducks such as the Ruddy Duck (*Oxyura jamaicensis*) of North America. For example, the tail feathers are elongated and stiffened for diving and maneuvering under water, the legs are placed so far to the rear that locomotion on land must be very difficult, the nest is built over water, and the eggs are large, white, and chalky. Thus it appears that the Musk Duck is an aberrant member of this specialized group of waterfowl, which includes seven other smaller species. Most of these have elaborate male sexual displays, including the inflation of the neck through the use of special tracheal air sacs or by the inflation of the esophagus. The Musk Duck lacks these structural features, but does have a subgular pouch connected with the mouth that allows for the enlargement of the throat. Although the lobe usually hangs quite loosely and resembles a piece of soft, black leather, it can be made thicker and turgid, presumably through muscular action or the expansion of the subgular pouch.

Indications of a remarkable behavior associated with these curious anatomical features have been evident for some time. Australia's pioneer ornithologist John Gould mentioned the strange sounds made by Musk Ducks, including the "plonk call," which he likened to the noise produced by dropping a stone into a deep well. The origin of this sound has baffled many people, some of whom have attributed it to vocal origin, while others have contended that it is caused by the wings, feet, or tail striking the water's surface. More recently, various ornithologists have described a sharp whistle associated with the elaborate kicking displays of the male. The female is thought to have only a few vocalizations, which is unusual among ducks. Partly to try to answer some of the many questions concerning this and several other species of Australian waterfowl, I went to southern Australia, aided by a research grant from the National Science Foundation. I hoped that a study of the behavior of these species would produce new evidence as to their taxonomic relationships and a better understanding of the evolution of behavioral differences in the family Anatidae. Although the more technical details of these studies have been published elsewhere, the Musk Duck provides such a perfect example of the effects of sexual selection on behavior and structure that its interest as a biological case study in evolution equals the curiosity value associated with any strange and exotic species.

While the Musk Duck has been reported to lack gregarious tendencies, it frequently does occur in flocks during the non-breeding season. At such times these gather on larger lakes and along the coast, relatively undisturbed by hunters and other predators. The birds are too large to be attacked by fish, and dive from sight when a hawk or an eagle appears. Like the smaller Ruddy Duck and the similar Australian Blue-billed Duck (*Oxyura australis*), with which it sometimes associates, the Musk Duck is a hardy bird. It is edible, and for a period of time there was a commercial attempt to can and market its meat.



**Female**, at left, is about a foot shorter than male. Note small wings, large feet, posterior placement of the legs.

**Profile** of swimming adult male, *above*, reveals unusually large lobe that hangs loosely when duck is not displaying.

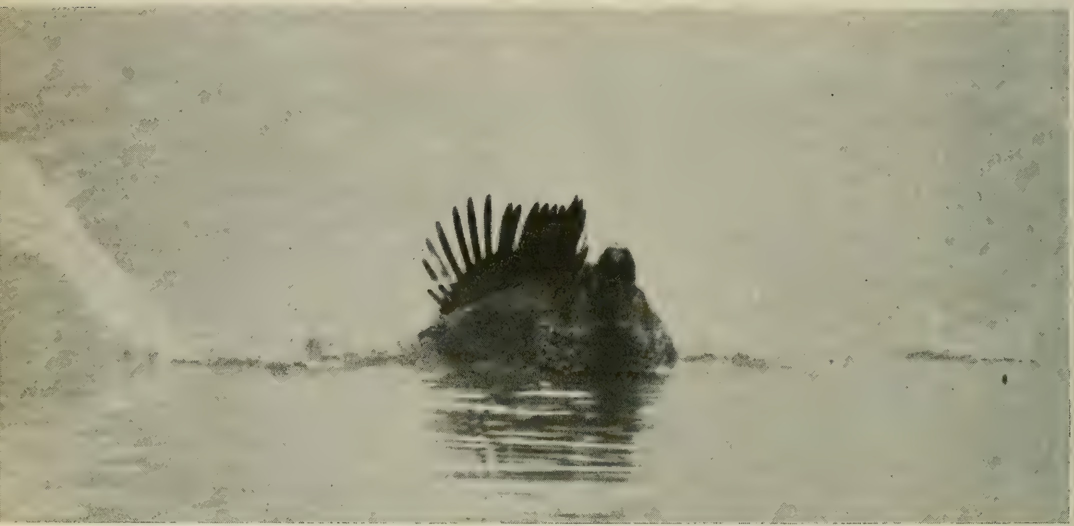
As the spring breeding season approaches, Musk Ducks move into places where permanent water areas exist, and which have substantial cover of emergent vegetation such as rushes and cattails. In such areas the males begin to attract the females by a combination of vocal and mechanical sounds and visual posturing.

Unlike the other stiff-tails, or ducks in general, there does not appear to be a true "courtship" that facilitates the formation of a pair bond lasting through the breeding season. Rather, the males indiscriminately display to all females, and probably associate with them only until fertilization is achieved, after which the female lays the eggs and tends them and young by herself. In this way the male is potentially capable of fertilizing a large number of females; the limit simply depends upon the availability of females and the distance from which they can be attracted. Thus the conspicuous nature of the displays is explained through sexual selection as determined by the differential abilities of males to attract females on the basis of their varying appearance and their behavior. (The younger males have smaller pouches and possibly display with less vigor.) In this way the presence of the pendent lobe and inflatable throat pouch, which enhance the visual aspects of display, seems explainable, and the loud splashing and calling provide important auditory stimuli. However, there is no evidence that the females are sensitive to the musky odor of the males. The surprisingly large size of the mature males may also be related to sexual selection, but certainly must also be partly a result of their aggressive tendencies. When a male is displaying to one or more females—frequently several will be attracted simultaneously — other males sometimes also approach the group. Should such an "onlooker" male move too close to a female, the displaying bird will suddenly rush toward him across the water surface or, more commonly, dive submarine-fashion and attempt to attack him from below. Usually the intended victim frantically retreats at the first indication of an attack, but occasionally a vicious battle ensues, with biting, wing beating, and scratching all combined amid a frenzied splashing of water. Smaller and weaker males are probably lucky to emerge from such a battle without broken bones, and thus a distinct advantage accrues to the larger and stronger. This, then, could well account for the evolution of the extreme sexual dimorphism that exists today.

In the displays of the male Musk Duck, we can see an interesting hierarchy of forms that appear to represent increasing degrees of modification and exaggeration of normal behavior and reflect probable stages in the evolution of these displays. Not only do the postures become progressively more unlike normal swimming postures, but also the time intervals between them become more constant and predictable.

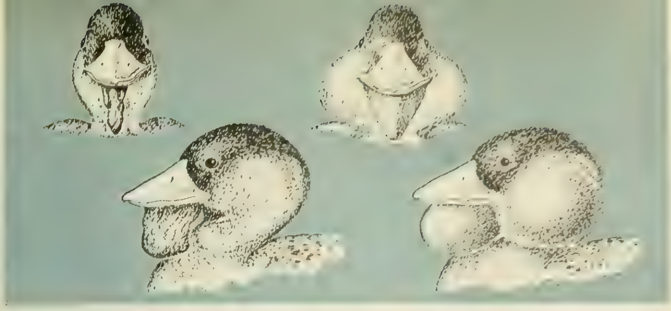
The simplest of these displays consists of a vigorous backward thrust of the feet that produces a "paddling kick," in which a sheet of water is thrown upward and backward six feet or more. Clearly this display derives from a stronger than usual paddling movement, thus resulting in both visual and auditory stimuli, but lacks marked posturing or associated calling. Paddling kicks are repeated at irregular intervals of several seconds.

The second display, or "plonk kick," is made up of variable tail cocking, lobe and throat enlargement, and a simultaneous kick by both feet. Unlike the paddling kick, which is primarily directed backward, the plonk kick tends to throw water out laterally, and both legs are momentarily lifted from the water as they are pulled backward. As the feet enter the water their outstretched webs strike the surface, thus producing the distinctive plonk sound associated with the display. These kicks are indefinitely repeated at intervals of approximately three seconds, with only slight variation.



**Splashing**, *above*, is part of male's "plonk kick" display during which both feet strike the water with a loud smack.

**Elongated**, stiffened tail feathers, *right*, help the ducks in diving and maneuvering under water. Bird in rear is asleep.



**Drawings** at left show how lobe and neck look normally. At right, lobe is turgid during courtship display, as throat and subgular pouch are inflated.

As females are attracted by the noise and water movement, the male replaces the plonk kick by the most complex display, the "whistle kick." Extreme tail cocking, lobe enlargement, and throat inflation are associated with this display, which consists of a relatively weak lateral kick of both feet and a simultaneous, sharp whistle. Between kicks the body is often flexed upward to an extreme degree, as the bill is raised and the tail is bent forward until it touches the back. The interval between successive whistle kicks averages over three seconds and rarely varies by more than a quarter-second.

This species is perhaps unique in that no special preliminary displays are apparently associated with actual mating. Rather, the male quite suddenly mounts and copulates with one of the females he has attracted. This "primitive" method of mating probably simply reflects the fact that pairing in the species is non-existent and, as a result, there is no need for synchronization of sexual stimulation or pair-bond maintenance mechanism.

After copulation, the females move into dense growths of rushes or similar emergent plants and construct their nests. Sometimes the nest is built on the branch of a tree that has been partially submerged, as often happens during the flooding of lowlands in rainy years. The incubation period of Musk Ducks is another of the many points of its life history that still remains unknown, but it is probably as long as, or longer than, the three-week period of the smaller stiff-tails. The downy young are extremely precocial, swimming and diving shortly after hatching. Occasionally the young have been reported to ride on the mother's back as she swims about partially submerged. According to one authority, the downies grasp the feathers of the mother's neck, and during times of danger she may even dive with the young clinging to her.

Although few people have observed adult males in flight, I have witnessed flights by females or immature males on several occasions. In each case there was a strong offshore wind, the birds were in rough water near the middle of a lake, and they flew toward the calmer water near shore. Actual flight was not attained until the birds had "run" for about forty yards or more over the water, and even then an altitude of only a few feet above the surface was reached before they "crash-landed" into the water again. In general, it appears that most flights are undertaken at night, and several instances of nocturnal accidents are on record, such as when birds have flown into the sides of buildings.

There are a few cases of Musk Ducks having been kept in captivity for various periods, and one male even survived for six years in the Berlin Zoo during the early 1900's. This bird terrorized almost all the other waterfowl on its pond by attacking them under water; its appearance would consistently cause a fast, general retreat to the shore by all other ducks.

# SKY REPORTER

## Potential lifetime of a star depends on the rate of fusion

By Thomas D. Nicholson

**Bright stars** in cluster Messier 67, *below,* are four or five times brighter than the sun and about five billion years old.

**Double cluster** in Perseus has stars 10,000 times brighter than sun. Its age is estimated to be only a few million years.

IMPORTANT in the chain of events that led to our current knowledge concerning the birth and the death of stars was the discovery that the earth must be at least several billion years old. The many signs that indicate the age of the earth include the study of fossils, ocean salinity and sediments, and the age of surface rocks. More important, these signs show also that the earth has been receiving approximately the same amount of solar energy through most of its existence as a solid world. Of great significance to astronomers, they can measure—by the amount of radiation that falls on earth—how much energy, in the form of light, heat, and other kinds of radiation, the sun gives off in a second, a day, or a year. From the earth's history, they know that the source of this energy from the sun had to be great enough to continue the supply for at least five billion years.

What is the source of the sun's energy? The physics laboratory provided the answer. Observation showed that the principal chemical element in the sun, and in all stars, was hydrogen (the lightest known substance). Investigations proved that enormous quantities of energy would be released through fundamental changes in the structure of atomic nuclei. If heavy elements could be split (fission), energy would be liberated. If light elements could be combined (fusion), again energy would be released. One such process, the fusion of hydrogen into helium (the next heavier element), could occur at the temperatures that must exist deep within the sun. A theoretical consequence of the Einstein special theory of relativity ($E=mc^2$) showed what quantity of energy would be radiated by the process. Knowing the amount of energy this process could supply, astronomers calculated that the sun would have to consume about six hundred million tons of its hydrogen each second to manufacture the energy it was observed to radiate, if hydrogen fusion was its energy source. How long could the sun sustain this process? Would its hydrogen supply last—at the enormous rate it was being consumed—for billions of years? Calculations showed that the sun's hydrogen supply is sufficient to sustain fusion reactions for at least ten billion years, and it may be that the supply is enough for possibly twice that long.

The potential lifetime of any other star should depend on how much hydrogen it has available and how rapidly it is being consumed. But when this simple logic was applied to stars other than the sun, there were some surprises. The hot, brilliant stars of the universe are known to be about ten thousand times more luminous than the sun and therefore are producing energy at a rate about ten thousand times greater than does the sun. If these stars also had ten thousand times as much material as the sun, they could shine as long. But it turns out that these brilliant stars have only about ten times more material than the sun, and they are using it ten thousand times faster. From this we know that their life spans are about ten million years.

On the other hand, there are faint, cool stars known to be only about one-thousandth as luminous as the sun. Their life spans would be comparable to the sun's if they had one-thousandth as much material as the sun, yet they actually have about one-tenth as much hydrogen. Since the stars are using their hydrogen at a much slower rate than the sun, it is estimated that these faint, cool stars will outlast it by about one hundred times; they have life spans as normal stars of one thousand billion years or longer.

LAST month we observed that modern astrophysical theory predicts that stars, after they have used their supply of available hydrogen, evolve into red giant or supergiant stars—luminous, cool, and red. Now we see that the large, hot, brilliant stars of the universe should evolve rapidly, and the small, faint, cool stars should evolve slowly. Looking at a single star in the sky would give us no idea how old it was, but we could tell, from its luminosity and its mass (these, in normal stars, are always related), what its potential lifetime should be; seeing a group of stars in the sky, and having some indication that all the stars of the group were about the same age, we could estimate the maximum age of the aggregation by identifying the luminosity of its brightest stars. Presumably there may have been stars in the group even brighter than the brightest ones we now observe, but these, with life spans shorter than the age of the group, should already have consumed their hydrogen supply and evolved into red giant stars.

The laboratory for testing our theories of stellar evolution, therefore, is in the groups, or "clusters," of stars we find in the sky, in which all the stars are approximately the same age and of a similar chemical composition. In all, we

**Expanding** nebulosity is shown surrounding Nova Persei in this photograph taken with 200-inch telescope at Palomar.

know of about a thousand such clusters, classified into two known types. There are about one hundred or so globular clusters ("Sky Reporter," January, 1965), distant, compact clouds of many thousands of stars of the same kind. We have reason to believe that the stars in these clusters are among the oldest in the universe, for they contain no normal bright stars more luminous than the sun, their brightest being red giants. About nine hundred open clusters are known, each containing a few dozen to a few hundred stars, and because they are always found within the Milky Way, these are also called galactic clusters. The stars of such groups are physically associated and are held together by the gravitational force of the cluster itself; they have a common motion in space and are similar in chemical composition. There is every reason to believe that they were formed from the same cloud of interstellar gas. If so, the stars within a given cluster should be about the same age, and an analysis of the stars within the cluster should show its maximum age. A comparison of star clusters themselves can show us whether our ideas of stellar evolution are correct.

THE study of such star aggregations has clearly confirmed the theories of stellar evolution. For each cluster, the brightness and the color (or temperature) of each star within it is observed. These two characteristics of the stars are then plotted in a diagram of brightness against color. This locates the series known as the main sequence (the heavy curved line in the diagram at right) of color and brightness. The age of the cluster is identified by the brightness at which the brightest stars of the main sequence terminate. Stars higher on the brightness scale have presumably evolved off the main sequence.

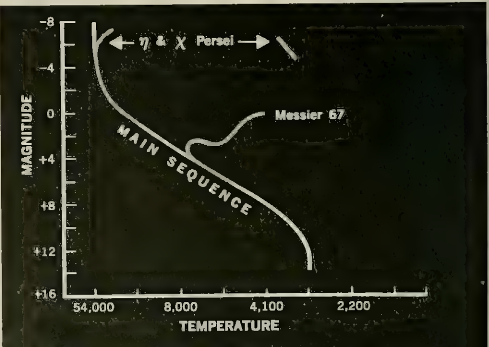
When this analysis is done for a variety of groups, a clear pattern evolves. The brightest stars on the main sequence in each cluster are found slightly to the right of the line, indicating that they have begun to cool and redden. Fainter stars than these lie along the main sequence and brighter stars than these are not observed there. But a red giant branch of stars is found on the diagram for each cluster at about the position where those brighter stars would be expected to evolve.

The two star clusters illustrated in the photographs on pages 30-31 represent the extremes of age. The positions of the main sequence and the red giant branch for these particular clusters have been drawn on the diagram shown below. The double cluster in Perseus, Eta ($\eta$) and Chi ($\chi$), contains as its brightest stars some that are about ten thousand times more luminous than the sun. Its age has been estimated as only a few million years. Note in this diagram how its brightest main sequence stars have evolved slightly to the right (cooler and redder) of the main sequence. Note also the red supergiant stars, far to the right of the series, representing those of this group that have already evolved completely off the main sequence.

**Dr. Nicholson**, the regular author of this column, is also Chairman of the **American Museum-Hayden Planetarium.**

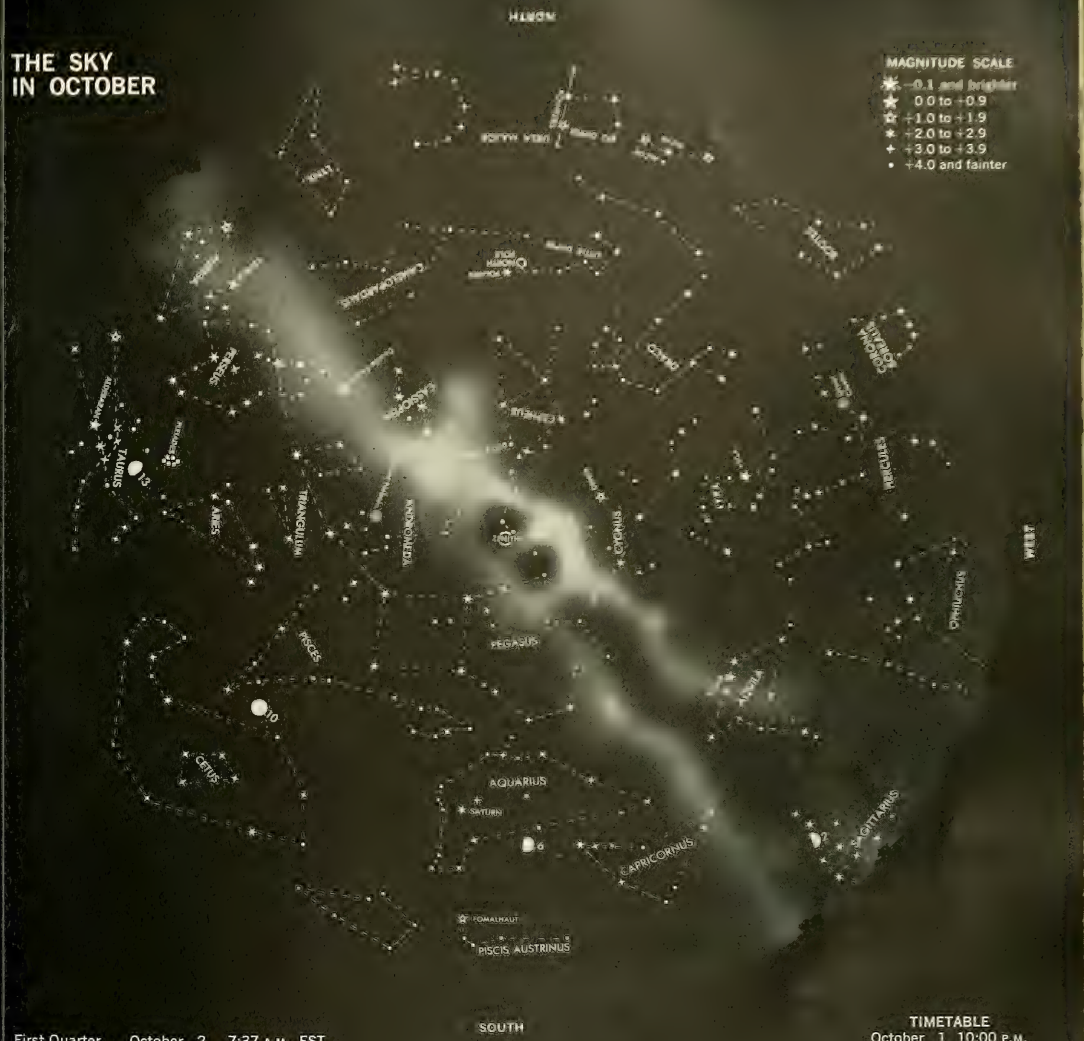
The cluster known as Messier 67 is estimated to be about five billion years old, however. The brightest stars of the series in M 67 are only about four or five times brighter than the sun. All brighter stars of this cluster have already evolved off the main sequence; thus the cluster must be at least old enough to allow stars four or five times brighter than the sun to use up all their hydrogen. According to theory, these stars should evolve into red giant stars. Note the branch of M 67 stars that curves off to the right and then upward into the red giant branch. These are the stars of M 67 that have already used up their total lifetimes as normal hydrogen-burning stars.

Beyond the red giant stage of stellar evolution, the evidence to support our theory is much less convincing. We believe that white dwarf stars represent the last stage of stellar evolution, but so far we have little evidence to show how stars reach that stage. The stars that have already become white dwarfs should have been the brighter, more massive stars of the universe, yet white dwarfs have masses about equal to the sun's. A possible explanation is in the activity we observe in stars that become novae (exploding stars). As shown in the photograph of the expanding nebulosity surrounding Nova Persei, *above left*, these stars expel some of their matter in the form of exploding gas shells. The mass they lose in each outburst is relatively small, however, and does not seem adequate for the change that seems to be required. At any rate, we should not expect to know all the answers concerning the evolution of the stars. After all, we have only learned what a star really is within the past four decades.



Brightness at which the brightest stars along main sequence terminate identifies the age of the cluster.

# THE SKY IN OCTOBER


NORTH
MAGNITUDE SCALE
−0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
URSA MAJOR
URSA MINOR
NORTH POLE
CAMELOPARDALIS
BOOTES
CORONA BOREALIS
HERCULES
DRACO
LYRA
CYGNUS
CEPHEUS
CASSIOPEIA
PERSEUS
AURIGA
TAURUS
PLEIADES
13
ARIES
TRIANGULUM
ANDROMEDA
ZENITH
PEGASUS
PISCES
10
CETUS
AQUILA
OPHIUCHUS
WEST
AQUARIUS
SATURN
6
CAPRICORNUS
SAGITTARIUS
2
FOMALHAUT
PISCIS AUSTRINUS
SOUTH

| | | |
|---|---|---|
| First Quarter | October 2, | 7:37 A.M., EST |
| Full Moon | October 10, | 9:14 A.M., EST |
| Last Quarter | October 17, | 2:00 P.M., EST |
| New Moon | October 24, | 9:11 A.M., EST |

**TIMETABLE**

| | |
|---|---|
| October 1 | 10:00 P.M. |
| October 15 | 9:00 P.M. |
| October 31 | 8:00 P.M. |

(Local Mean Time)

October 7: Saturn is in conjunction with the waxing gibbous moon at 11:00 A.M. Saturn is to the left of the moon in the evening sky of the 6th, to the right and closer to the moon on the evening of the 7th.

October 10: The full moon this evening is the hunter's moon. The rising moon is retarded about 25 minutes each night from the 8th to the 11th.

October 15: Jupiter and the moon are in conjunction at 11:00 P.M., EST, shortly after moonrise. Jupiter will appear above and to the left of the waning gibbous moon as they both rise together.

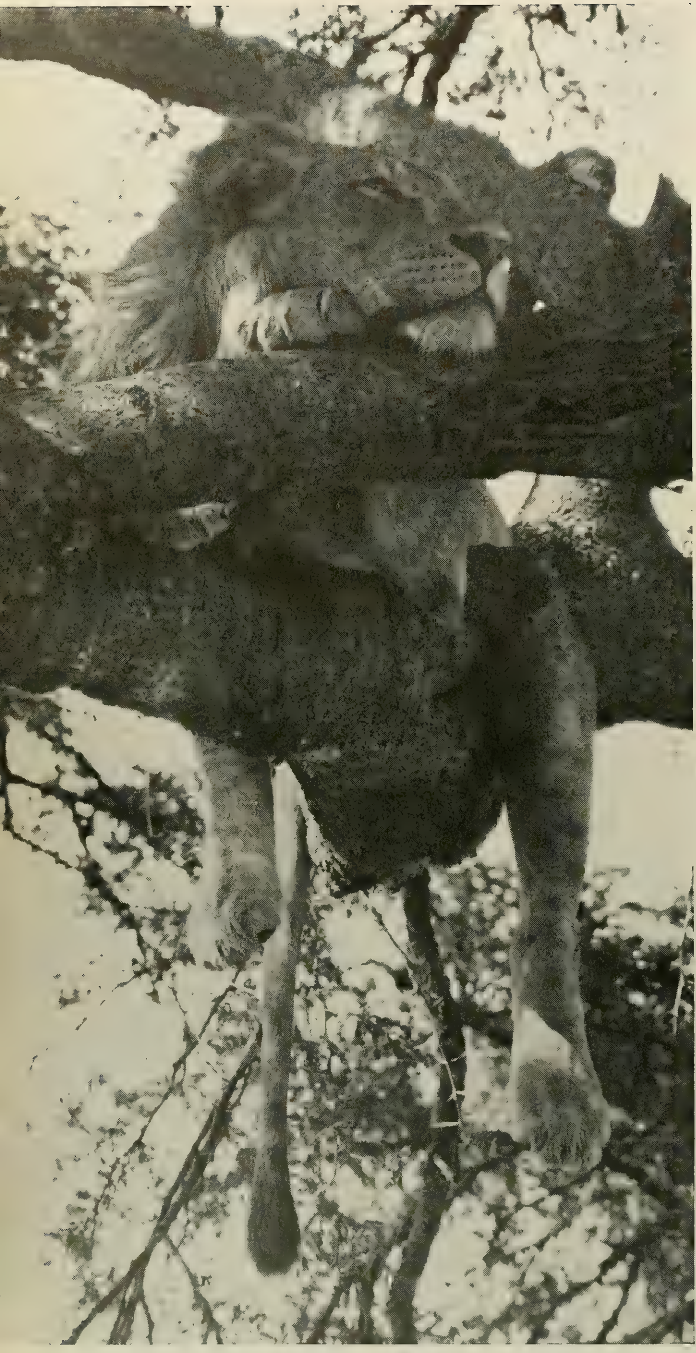
October 15-17: Mars, Venus, and the bright red star Antares, in Scorpius, present an interesting arrangement these evenings. In the west after sundown, Venus can easily be found by its brilliance. Two hours after sunset Antares and Mars can be seen, as the western sky grows darker. On the 15th, Mars will be to the left of Venus, and Antares will be still farther left; on the 16th, Antares will be between Venus and Mars. On the 17th, Mars will be to the left of Venus and Antares to the right.

October 18-19: Venus and Mars will reverse positions on these evenings. Conjunction (both planets in line from earth) is at 10:00 A.M., EST, on the 19th.

October 19: Jupiter is stationary in right ascension. From now until January 10, 1966, Jupiter will be moving retrograde (westward) through the stars of Gemini and Taurus.

October 20: The Orionid meteors, radiating from near the "club" of Orion, reach maximum (about 25 per hour).

October 27-28: Look for another interesting display from Venus and Mars. On the evening of the 27th, Mars is quite close to the crescent moon (conjunction is at 9:00 P.M., EST, just as the moon becomes visible in the twilight), and Venus is some distance to the left and above. On the 28th, Venus is in conjunction with the moon; in the evening sky, Venus is to the right and below the moon, and Mars, still farther to the right, is difficult to see without the moon or Venus as a guide. Jupiter will appear in the east several hours before midnight.



# SIESTA TIME — OR ROYALTY OUT ON A LIMB

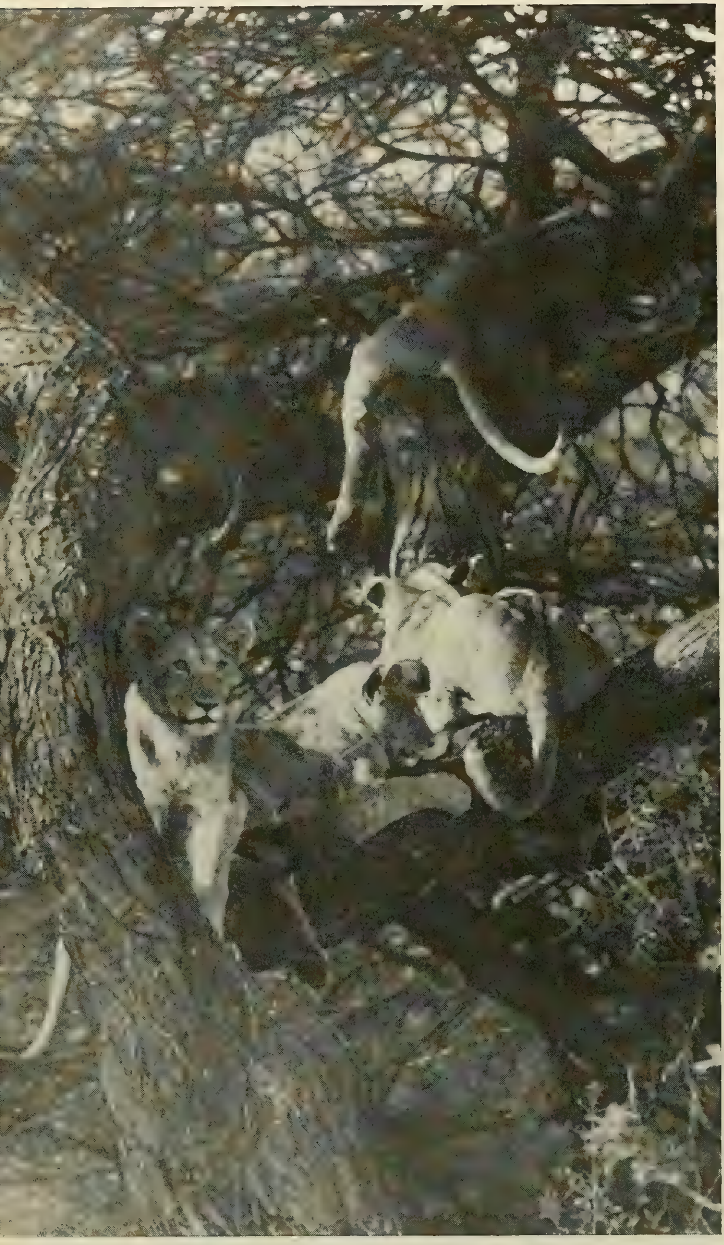
Sprawled rather unmajestically among the heavy branches of an acacia tree, the lions pictured on these and the following pages do little to further their image as the nobility of the animal kingdom. Well fed, hot, and lethargic, they have climbed into the tree for respite from the stinging flies and the devastating afternoon heat that scorches the African plains. The females and young males crawl well up the tree and out onto the extremities of the thick branches, but the heavier adult males, if they are able to get up at all, must settle themselves in the lower limbs. Once in the tree, the lions lounge in a variety of arboreal postures, dozing, scratching, and yawning until the heat abates. Then, as evening comes, the lions descend. On the ground, lethargy vanishes. Relaxed muscles are tensed, senses are alerted; the cat nap is over.

**A**dult male, *left*, somewhat resembles an impaled parachutist as he maintains a drowsy surveillance of plains below.

**F**emale, *right*, straddles the crotch of a tree with rear legs, braces herself with a front paw . . . and sleeps.

### by SALLY ANNE THOMPSON

# The Pace Is Not Quick

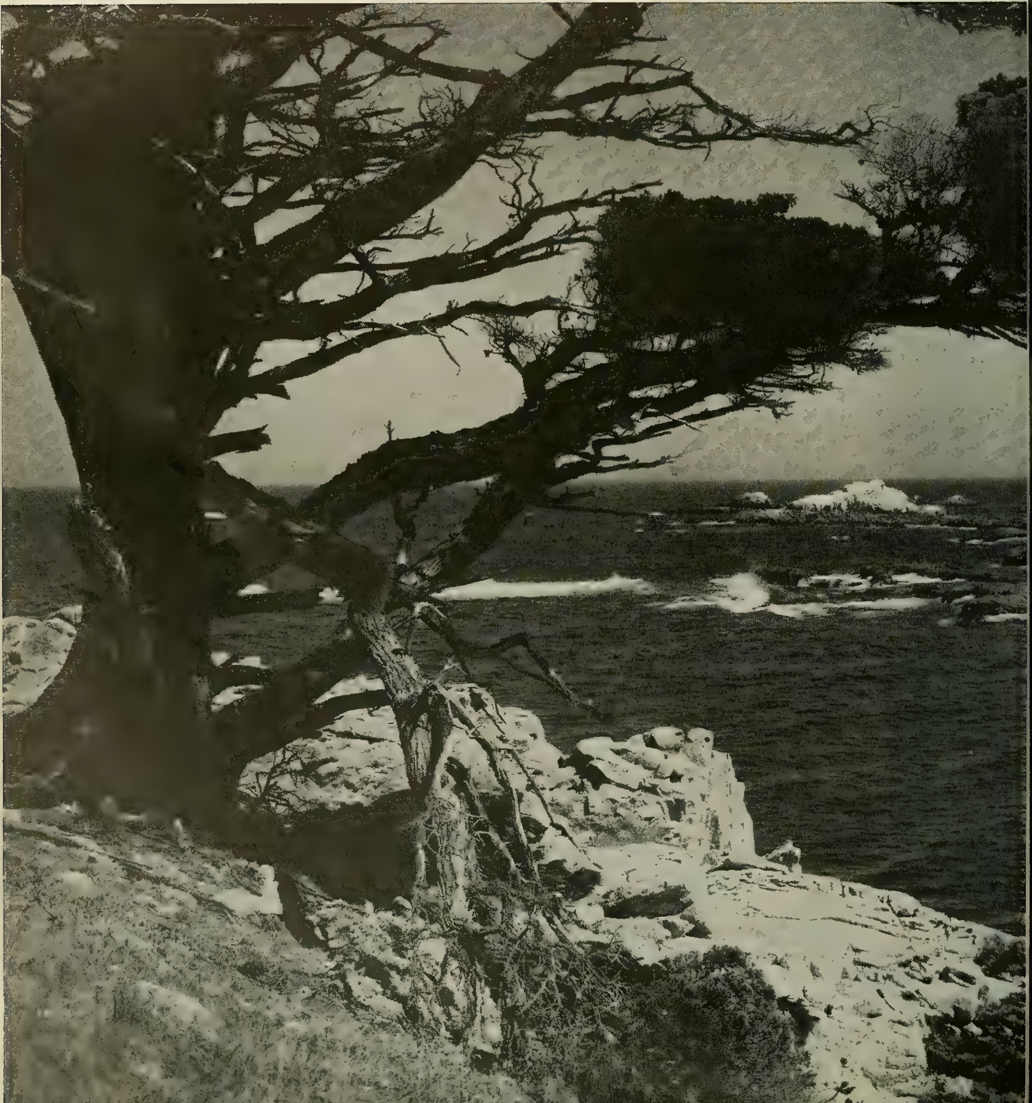


Total relaxation is achieved, *above*. An infrequent expenditure of energy may result in fly being flicked by tail.

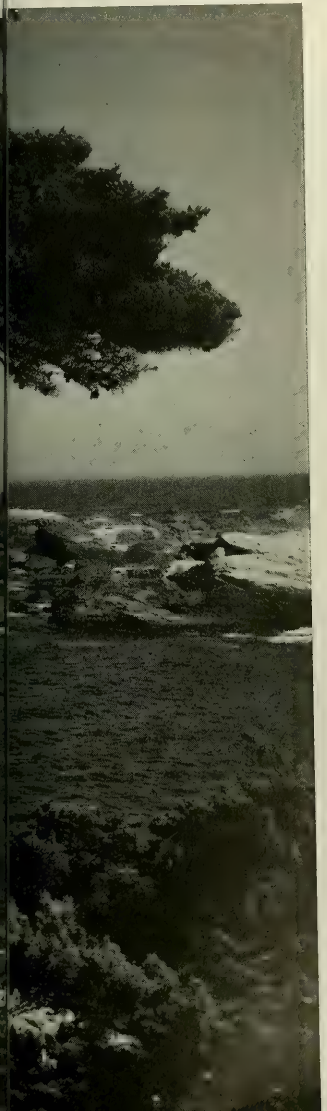
Cub sentinal, *left*, peers out from behind gnarled branch as other memb of pride doze on shaded limbs of acaci

Young lions, *right*, sprawl on high branch where flies are less numerous and there is the possibility of a breeze

# Rare Cypress Clings to Coast Habitat



*Thick grove, above, is often blanketed by fog that causes light, steady rain.*



*Monterey cypress, left, has long faced the force of California's coastal winds.*

# Overspecialization threatens tree's survival

### By Sherwin Carlquist

Fringing the wave-worn granite headlands that neighbor the town of Monterey, California, is one of the world's rarest trees—the Monterey cypress. California has many restricted native plants, isolated in small areas that furnish peculiar sets of circumstances required for their survival. The Monterey cypress is of particular interest within this category, however, first because of its stature, which is greater than that of other cypresses, and second because in the two narrow strips of coastline where it tenuously clings, it matches the rocky grandeur of sea cliffs with fantastic growth forms promoted by the stress of an oceanside habitat.

A few hardy individuals of this species face the brisk winds and salty spray where promontory slopes yield to precipitous cliffs. Although cypresses generally are of a dense columnar or conical form, the unprotected Monterey cypresses are twisted and open; their sparse, contorted branches a result of the gusts that buffet the shores of the Monterey Peninsula. Complementing the tattered crowns are flanged and buttressed trunks and spreading roots, built up in response to wind pressure upon the trees.

The two native groves of Monterey cypress extend only about half a mile inland from the high-tide line. Within this small area, however, are less wind-whipped zones, and there the trees grow in dense groves, where layer on layer of their deep-green branches form a dark, thick canopy. Through these groves seep the fogs that so frequently blanket Monterey. The sprays of foliage, their surfaces constantly brushed by mist, act as centers of condensation and cause a sparse but steady rain within the groves. Testimony to the frequency of fogs is found in the long festoons of a gray-green, lacelike lichen, *Ramalina reticulata*, which cover many of the cypress branches. Such luxuriant lichens are abundant only within a short distance from the coast. Some cypress trunks are covered with a furry, orange growth; this is a green alga, *Trentepohlia*. These lichen and alga adjuncts to the cypress groves require long periods of high humidity for growth and survival.

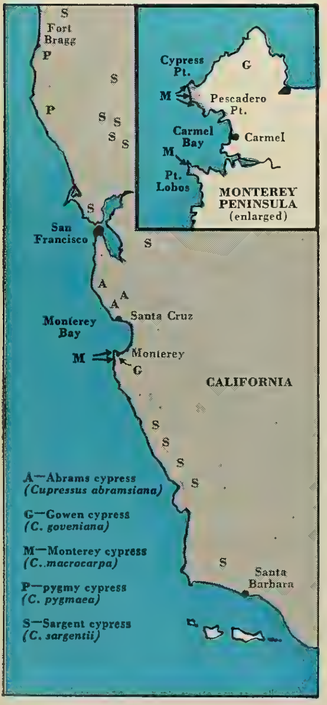
The foggy climate may be one of the reasons why Monterey cypresses are restricted to two small colonies in their native state. One of these stretches from Pescadero Point to Cypress Point on the southern edge of the Monterey Peninsula, and the other is nearby on Point Lobos. These two groves contain only about 10,000 trees, a diminutive number when compared with the total populations of most species of trees. Do these two cypress colonies represent a last stand of a once widespread species? If so, what factors have forced this tree into such a narrow edge of the Pacific

*Healthy cones of Monterey cypress are usually 1 to $1\frac{1}{3}$ inches in diameter.*

*Grayish-green, lacelike lichens hang from many of the branches.*

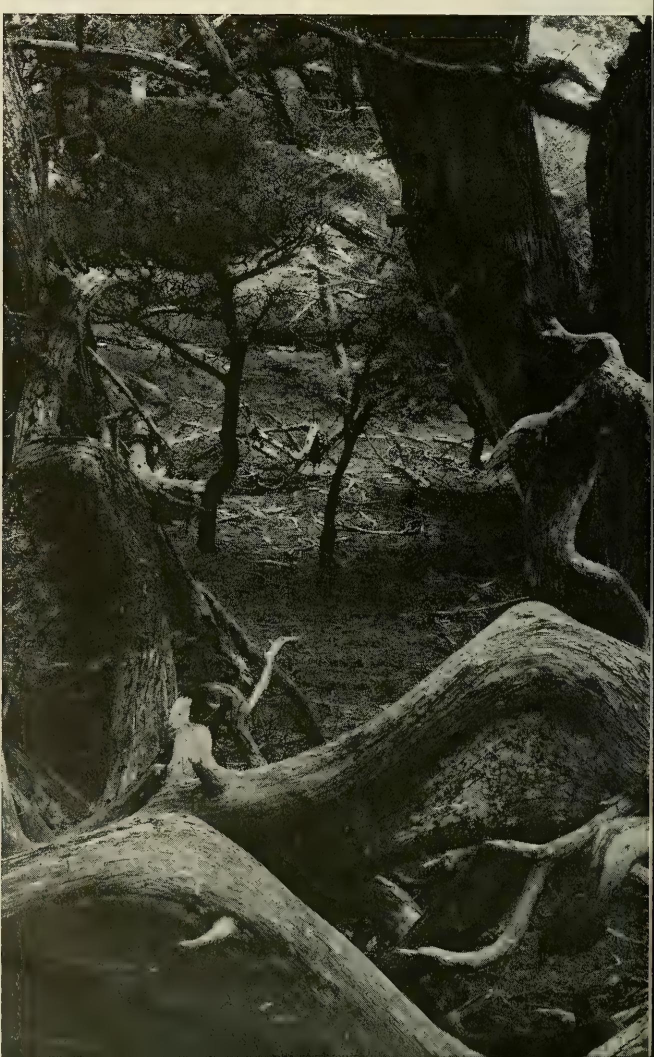
coast? Or has the Monterey cypress always been limited to such a small area? An intricate story, which can be pieced together partially, underlies the geographical restrictions of this tree.

The Monterey cypress, *Cupressus macrocarpa,* is not a "living fossil," distantly removed from other cypresses. Rather, species of cypress that are similar in appearance and morphological features live not far away; most of them are in California. These include the Gowen cypress (*Cupressus goveniana*), the Abrams cypress (*C. abramsiana*), the pygmy cypress (*C. pygmaea*), the Sargent cypress (*C. sargentii*), and the Mexican cypress (*C. lusitanica*). All of these have shaggy gray bark and large, rounded

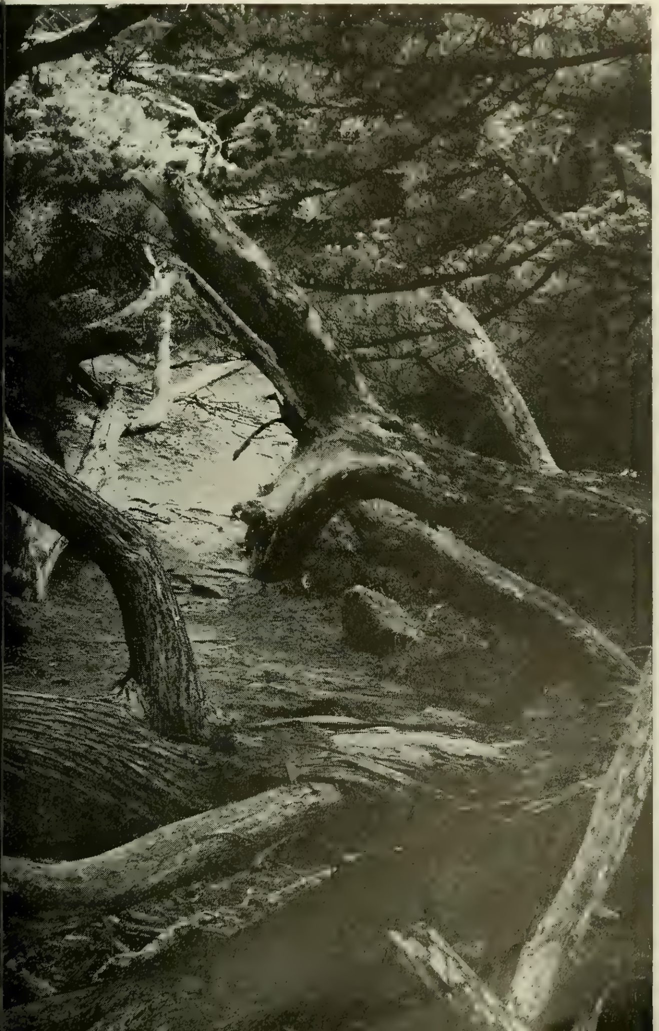

S
Fort Bragg
P
S
P
S S
S S
S
San Francisco
S
A
A
A
Santa Cruz
Monterey Bay
M
Monterey
G
CALIFORNIA
S
S
S
S
A—Abrams cypress (Cupressus abramsiana)
G—Gowen cypress (C. goveniana)
M—Monterey cypress (C. macrocarpa)
P—pygmy cypress (C. pygmaea)
S—Sargent cypress (C. sargentii)
S
Santa Barbara
Cypress Pt.
G
M
Pescadero Pt.
Carmel Bay
Carmel
M
Pt. Lobos
MONTEREY PENINSULA (enlarged)

*Monterey species grows natively in only two stands, both on the Peninsula.*

*Twisted roots spread out to buttress the cypress against wind's pressure.*



cones, and differ only in such relatively minor characteristics as size and shininess of seeds, color of foliage, and size and shape of plants. The Monterey cypress attains 60 to 75 feet in sheltered locations. The bark is thick, furrowed, and ashy-gray. The foliage is bright green. Young, vigorous shoots have twigs 4 mm. wide, with leaves 5 to 10 mm. long; less vigorous branchlets on older portions of the tree are 2 to 3 mm. in diameter with leaves only 1 mm. long. Mature cones are 25 to 35 mm. in diameter, and the irregularly disk-shaped seeds are often 5 or 6 mm. long. The most striking differences among these species are those of geographical distribution, which are based upon their respective tolerances of particular soils and climates. The Gowen cypress is even rarer than the Monterey cypress, of which it is a close neighbor. Gowen cypresses inhabit only a single slope on Huckleberry Hill near Monterey. Here they grow amid a stand of Monterey pines in acid, sandy soil. The Abrams cypress is also rare —it appears only in three colonies in the mountains behind Santa Cruz, California. One of these colonies grows on white sand, the other two on granite. Abrams cypresses are native to hillside slopes 1,600 to 2,500 feet high—well above the coastal fogs—and grow within a dry, scrubby vegetation. The pygmy cypress grows in the barren, powdery-white, alkaline flats near sea level at Fort Bragg in northern California. There the harsh alkalinity and hardpan rocks underlying the shallow soils combine to dwarf these trees. If grown on a normal soil, the pygmy cypress attains large size, but it will establish natural colonies only on the alkaline barrens, which are clearly required for uncultivated species survival. Mature trees are only one or two feet tall. Far more tolerant of a variety of conditions is the Sargent cypress, which is found from Mendocino County in northern California to Zaca Peak near Santa Barbara in southern California. Sargent cypresses inhabit dry, inland, hillside slopes of California's coast ranges and are shrubby trees 30 to 45 feet high at most. Cones range from 15 to 25 mm. in diameter, and thus are much smaller than those of the Monterey cypress. Far to the south the Mexican cypress, which grows even at relatively high elevations on volcanic pumice, occurs from central Mexico to Guatemala and Costa Rica, mostly at altitudes from 6,000 to 7,000 feet.



When the Monterey cypress is viewed as part of this assemblage, it no longer seems an isolated plant, but a part of a larger pattern. Cypresses tend to occur, not in continuous forests within a mountain range, but in separate groves. Smaller populations of this sort permit plants to evolve more rapidly, because larger populations have more "stability," are less easily swept by some change than are a few individuals. Thus, some groves of a hypothetical ancestral cypress species may have drifted toward adaptation to coastal situations, some toward inland ones; some developed preference for acid, others for alkaline soils. The Monterey cypress, therefore, represents adaptation to a single set of conditions—an adaptation that probably occurred during a period of active differentiation by the shaggy-barked California cypresses. If conditions to which a plant adapts are limited in geographical extent, the plant obviously does not expand beyond those limits. The Monterey cypress, for example, has become adapted to cool, fogbound shores. This fog serves to reduce the summer temperatures, and the seaside climate also renders winters more mild than those of inland areas. Although rainfall at Monterey is modest (between

15 and 20 inches per year), the ability of the cypresses to condense drops of water out of fog increases this total within a cypress grove. Soils become dry during the California summer, offering little ground water for trees. However, the moist air at Monterey decreases evaporation, so trees do not need as much ground water as they would in a less foggy climate.

Without a doubt, these more moderate moisture and temperature conditions favor the growth of a large tree. The pines and redwoods near Monterey indicate that large trees are possible in this location. Most of California's drier inland hills are covered by scrubby chaparral, the tough-leaved shrubs that are a dominant part of California's hillside vegetation. The Sargent cypress is just such a chaparral plant, a status reflected in its smaller, shrubby stature and its gray, waxy foliage, which resists desiccation better than the non-waxy, green branchlets of the Monterey cypress. This contrast between larger coastal plants and smaller inland relatives is apparent not only in the cypresses, but also in chinquapins, tanbarks, and several species of oaks. Larger coastal trees owe their size to better, more continuous growing conditions—more moisture, less desiccation, more even temperatures.

With respect to soil, the Monterey cypress seems wedded to granite—a rock that produces a rather acid soil, varying from a pH of 5.5 near the surface to 4.5 near the parent rock. This acidity is maintained and magnified by the accumulation of dead foliage beneath the trees. If one looks at a geological map of California, one finds a strip of undivided rocks of Jurassic age that reaches from the mountains behind Monterey down to the Monterey Peninsula. The two spots where Monterey cypresses grow are not the only places at which granite rocks meet the coast; there is another stretch of granite coastline not far to the south. Why doesn't the Monterey cypress grow there as well? Perhaps only on the Monterey Peninsula is there a coincidence of certain ecological conditions—many still unknown—that are required by the cypress. The deeper soils of the relatively flat Monterey Peninsula may be more favorable than the high granite headlands farther south, which drop steeply from fog-free elevations to the sea. Such slopes probably offer insufficient pockets of soil for cypress groves, like those near Monterey and Point Lobos, to develop and maintain themselves. Near Monterey, air is moister than along coasts to the south, yet Monterey does not experience the colder, rainier winters of northern coasts.

In addition to ecological requirements, there may be another important reason why the Monterey cypress occupies such a small niche. This reason is best explained in the botanical and horticultural history of the tree. It was supposedly first brought to Europe in 1838. We know definitely that specimens were gathered at Monterey in 1846 by the German botanist Karl T. Hartweg, who collected under the auspices of the London Horticultural Society. These specimens were used by Hartweg when he prepared the description of the tree he named *Cupressus macrocarpa*, and seeds from his collection were grown into trees in England. Soon, this tree gained favor in various parts of the world as a garden tree or as a windbreak. In Australia, New Zealand, and South Africa the Monterey cypress proved to be a tree that grew quickly and attained far greater size than in its native habitat. In the nineteenth and twentieth centuries, the tree was enthusiastically planted around residences in California's cities and suburbs. On California farms, the spreading forms of Monterey cypress trees made good windbreaks.

Soon, however, signs of trouble became apparent. In 1928 a disease, the cypress canker, was reported from Monterey cypresses in middle western California. In California and in other parts of the world, Monterey cypresses grew rapidly, but they showed a distressing tendency to deteriorate quickly, as well. Over a period of years, growers observed that one branch of a tree, then another, would turn brown, leaving a progressively sparser tree that eventually died. Also evident were rows of blackish pustules in cracks along the bark, and these proved to be the key to the trouble. In these pustules were borne the spores of *Coryneum cardinale*, a fungus that caused cypress canker.

Cypress canker, which has proved to be virtually impossible to control once it has attacked a tree, is a disease native to North America. Most susceptible to the canker are Monterey, Abrams, Gowen, and pygmy cypresses, in that order; to a lesser extent, Sargent and Mexican cypresses are also susceptible. Other cypresses are rather resistant. Spores of the fungus enter the tree through injuries, breaks, or thin spots in the bark. The Monterey cypress has proved to be exceptionally susceptible to the ravages of *Coryneum* at localities other than Monterey itself. This leads one to ask: why not at Monterey?

Some plant disease experts, viewing the ocean-oriented distribution of cypresses native to Monterey, hypothesized that the salt spray inhibited growth of the fungus. Experiments showed that in distilled water 72 to 84 per cent of the fungus spores germinated, whereas in tests using glass slides covered with a film of sea water, 4 per cent or less of the spores grew. Ordinary table salt was also shown to decrease markedly the germination of spores. This evidence suggests that a continual light mist of salty spray from the ocean may sharply reduce the danger of infection, although this does not appear to be the only reason why cypresses on the Monterey Peninsula are free of the disease.

Of the cultivated specimens of *Cupressus macrocarpa* in California, the healthiest are those within a mile or so of the coast. Does this attest to the fungus-inhibiting action of marine air, or does it indicate that Monterey cypresses near the coast resist infection better because they are healthier? Both are probably true. Inland, Monterey cypresses grow rapidly, but even uninfected specimens appear sickly and rarely form cones. Under these conditions, they may be weakened by excessively hot summer weather or cold winters. Such trees would be easy prey for infection.

An additional factor in the fungus infection may be the nature of the groves. At Stanford University, which is several miles inland, a dense and healthy grove of Monterey cypresses was at first thought to represent a fungus-resistant strain of the species. Later, trees were cut out to thin the grove. The remaining trees quickly showed signs of infection and soon succumbed to cypress canker. Cypresses in dense groves suffer less wind injury, which might provide sites for entry of the fungus. The accumulation of dust and lichens on branches within a dense grove may inhibit entry of the fungus, and these accumulations might even harbor harmless saprophytic fungi, which would offer antagonism to the canker fungus. Nevertheless, we can hypothesize that the Monterey cypress grows natively only in its two small stands near Monterey because it is a species precisely adapted to Monterey climate and soils. As a result, it is healthiest there. Because all other locations provide conditions less optimal than those of the Monterey Peninsula, cypresses elsewhere will be less healthy in varying degrees—if they succeed at all. Thus, trees in other localities might not be able to establish groves, except in rare cases, and such exceptions might be weaker than at Monterey and unable to resist disease.

With such small numbers of individuals and with such a long life span (up to 180 years), the Monterey cypress has little chance to develop fungus-resistant strains. Disease resistance can be developed most easily in plants with short life cycles, because genes for disease resistance can rapidly be transmitted to offspring. The larger the number of individuals, the greater the possibility for building disease resistance, because within a population only a very few individuals, if any, contain a disease-resistant mutation. On the other hand, fungi evolve quite rapidly, and the cypress canker fungus could theoretically maintain its effectiveness against whatever degree of disease resistance the cypresses might develop over a long period.

Even with limitations such as these, and with such narrow preferences for climate and soil conditions, the Monterey cypress may be able to exist for many centuries more. But in the long span of geological time, it may well have inextricably "painted itself into a corner" by overspecialization. Even without depredations caused by ever expanding human activities, many plant and animal species, both today and in the geological past, have become extinct by reaching evolutionary dead ends. In the Monterey cypress, we may be witnessing a "last stand" of a sort that has occurred many times.

*Coastal cypresses are not attacked by fungus that kills this species elsewhere.*

# Dorylines: Raiding and in Bivouac

### By T. C. Schneirla

## BROOD IS KEY TO CYCLES IN LEGIONARY ANTS

The doryline, or legionary, ants of the world are all raiders, living mainly on arthropod prey, and are all nomadic, without permanent nests. As one of the eight or so subfamilies of ants, they are specialized along these lines, presumed to be an ancient offshoot from the primitive ponerines, which arose from the wasplike ancestors of all ants. The dorylines—in contrast to their probable ancestors, the early ponerines, which themselves have continued as a large, distinct subfamily characterized by raiding behavior, a carnivorous diet, and relatively small colonies—have maintained the predatory pattern but with much larger colonies and with strong emphasis upon large group forays and nomadism as their way of life.

Doryline genera differ greatly among themselves in the degree and the nature of their specialization of the common subfamily behavior pattern. The most primitive and simplified of all may be the genus *Aenictus* of the Old World. Although *Aenictus* interested me increasingly from the time of my first research on American dorylines in Panama, it was thirty years before the circle rounded so that I actually could see and study the *Aenictus* genus in the field.

My research began with army ants of the tropical American genus *Eciton*, perhaps the most specialized of all dorylines. In this genus, *E. burchelli* and *E. hamatum* are among the few species of all *Eciton* (and hence of all dorylines) well adapted behaviorally and biologically to surface conditions.

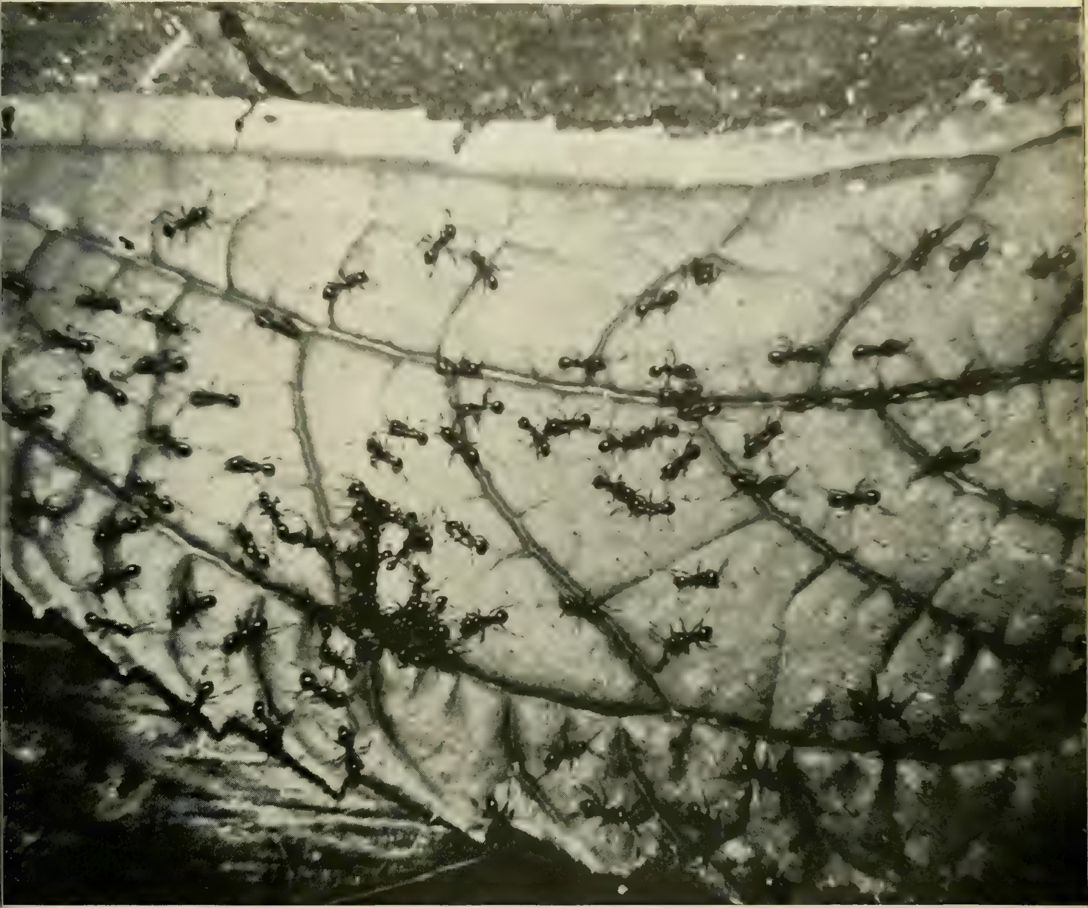
*E. burchelli* and *E. hamatum* are closely similar in the external structure of their queens, males, and workers, and so are regarded by systematists as closely related. The anatomical similarities in their worker series—which are polymorphic, or differentiated both in size and structural gradations from the minim to the major workers—are indicated on page 47. Although the two species are much alike in their degree of surface adaptation, some important differences exist between them, particularly in their patterns of raiding and in their typical prey. *E. burchelli* is the well-known tropical American swarm raider, an excitable ant whose mass forays are large and complex (in Panama and Mexico I have seen their advancing swarms exceed 65 feet in width), whereas *E. hamatum* is a less excitable ant whose raids are marked by widely branched columns extended into new terrain by small groups that also begin pillaging operations. The striking difference in the typical raiding patterns of these two species is represented on page 49. The species also differ greatly in their booty. *E. burchelli* captures a wide variety of arthropod prey ranging from spiders and leaf-insects—torn up and carried back in pieces to the temporary nest—to ants and their brood; *E. hamatum*, in contrast, specializes on ants and their brood carried, as a rule, in whole.

Perhaps the most striking aspect of behavior common to the two species is that of the functional cycle, which presents two alternating phases. One of these phases covers an interval of species-typical length in which the colony carries out vigorous daily raids that generally end in nighttime emigrations to new nesting sites. I have called this the "nomadic phase." The other also involves an interval of species-typical length in which, however, raids are small or sometimes absent and emigrations highly exceptional. This I have called the "statary phase." The nomadic phase in *E. hamatum* usually lasts 16 to 18 days, in *E. burchelli*, 12 to 17 days; the statary phase is usually 20 or 21 days long in both species. Because the durations of these phases (hence of the successive cycles of any colony throughout the year) depend upon the interactions of complex functions based upon the properties of brood, queen, and workers, these values, predictable for each species, seem phenomenally precise.

The fundamentals of the cycle, first worked out for these *Eciton* species, may be summarized briefly. Each statary phase in *Eciton* ends when a large new brood matures and emerges as young workers, an event that so greatly arouses the colony as to shift it at once into high, so to speak, in a new nomadic phase. The basis of the excitation lies in a variety of mass-stimulative tactual and chemical effects exerted upon the colony by an emerging

AREA of the *Aenictus* investigation was on Negros Island in the Philippines. The Mindanao Sea is in the background.

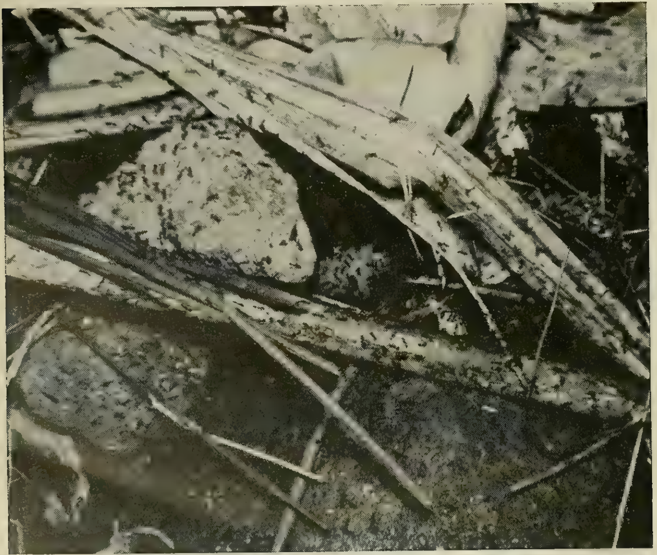
WORKERS of *Aenictus* move over leaf bridge on raiding trail with insect booty. Large piece is carried by group at left.



brood of callow workers. These workers take a few days for their postpupal maturation, during which the colony remains in its newly excited condition. The large broods of *Eciton* overlap in time so that a new brood of young larvae becomes the major energizer of the colony as the stimulative effect of the callow brood falls to the level of the regular adult workers. As the new larval brood grows, its effect on mass arousal also increases, and the colony stages more and more vigorous raids and emigrations. But as soon as these tens of thousands of larvae become mature and spin their cocoons, their excitatory effect upon the colony quickly drops to a low level. Then nomadic behavior ceases and a statary phase begins. With a relatively low degree of stimulation from the brood, the worker population now raids only weakly, and the colony does not emigrate at all. The statary condition persists for about three weeks, or until the enclosed brood matures and, in its turn, introduces a high stimulative effect sufficient to set off a new nomadic phase.

COLONY behavior among these *Eciton* species maintains the described alternate phasic changes throughout each year. The nomadic and statary changes in each colony correspond closely in their duration to regular variations in the quantitative level of mass stimulation from successive great broods. I use the term "mass" for these effects because in these dorylines the members of any one of the annual series of all-worker broods begin and pass through the stages of their development at nearly the same time. In *E. burchelli* successive all-worker broods appear at intervals of about 36 days, each brood containing 200,000 or more individuals; in *E. hamatum* the interval is about the same, each brood containing about 80,000 young. These facts prepare one to appreciate what potent effects the broods can exert upon colony behavior as their activity levels and secretory properties change radically from one developmental stage to the next—rising steadily during the larval stage; falling to a low point held until near the

**Bivouac** of *Eciton hamatum* colony, now in its nomadic behavioral phase, forms an open cluster 20 inches high in hollow between buttressed roots.



**In contrast,** an *Aenictus laeviceps* colony gathers under dry leaves in a platter type of cluster. Both species are well adapted to surface conditions.

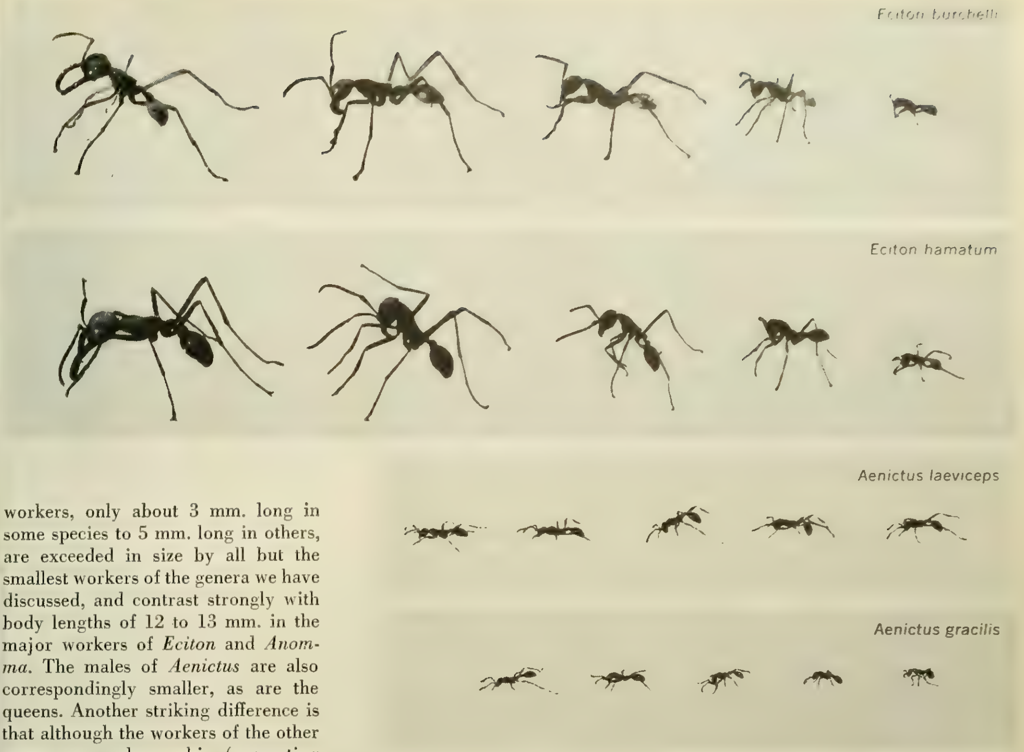
end of the pupal stage when a moderate rise occurs; rising abruptly with full pupal maturation and emergence as callow workers.

In another genus of American dorylines, *Neivamyrmex,* which I studied in Alabama and at the Southwestern Research Station of The American Museum of Natural History in Arizona, a comparable nomadic-statary cycle was demonstrated. Recently Mr. Howard Topoff, working in association with my project, obtained evidence that the workers of *N. nigrescens* show a sharply higher condition of physiological activity (as in oxygen consumption) during a nomadic phase than during a statary phase. As would also be expected from my theory of brood stimulation, this level normally increases through the nomadic phase to a high point reached near the end, but is abnormally low in colonies with greatly reduced larval broods.

The known species of *Eciton* and *Neivamyrmex,* although distinctive structurally and in many aspects of their behavior, resemble one another so closely in the phase durations and evident brood-stimulative causation of their functional cycles as to justify our referring to them together as the E-N group in comparing them with other of the dorylines.

However, a different state of affairs seems to exist in other dorylines, such as the Afro-Asian driver ants in the genera *Anomma* and *Dorylus.* These ants, and apparently also the tropical American genus *Labidus,* present markedly variable activity schedules in which single emigrations of the great colonies occur at irregular intervals that range from a few days to around two months in length. Between emigrations, a colony remains at the same nesting site, raiding from it in different directions on some days—somewhat as colonies of the E-N group do in their statary phases. *Aenictus,* however, resembles the E-N genera in its colony behavior, and we may include it in an E-N-A group characterized by regular, clearly marked nomadic-statary cycles.

*Aenictus,* an Old World genus of more than 46 known species, ranging from Africa through Asia into the Philippines, New Guinea, and Australia, is distinctive in several respects. In contrast to the other four genera mentioned, the ants in all *Aenictus* species are relatively small. *Aenictus*



**Polymorphic** *Eciton* **workers, at top, are from 3 to 13 mm. long, while the monomorphic** *Aenictus* **workers, at bottom, measure about 2.7 to 3.5 mm.**

workers, only about 3 mm. long in some species to 5 mm. long in others, are exceeded in size by all but the smallest workers of the genera we have discussed, and contrast strongly with body lengths of 12 to 13 mm. in the major workers of *Eciton* and *Anomma*. The males of *Aenictus* are also correspondingly smaller, as are the queens. Another striking difference is that although the workers of the other genera are polymorphic (presenting differences in size and structure in a series ranging from the minim to the major workers), the workers of any *Aenictus* colony are nearly monomorphic (closely similar in size and structure). Still other differences are in colony and brood populations:

| SPECIES | ESTIMATED WORKER POPULATION | ESTIMATED WORKER BROOD |
|---|---|---|
| *Anomma wilverthi* | 10-20,000,000 | 1,000,000 |
| *Labidus praedator* | 3-6,000,000 | 800,000 |
| *Eciton burchelli* | 1,000,000 | 200,000 |
| *Eciton hamatum* | 250,000 | 80,000 |
| *Neivamyrmex nigrescens* | 150,000 | 50,000 |
| *Aenictus laeviceps* | 100,000 | 35,000 |

My interest in *Aenictus* dated from the time when, shortly after my *Eciton* work began in 1932, I read a paper by the eminent Italian ant taxonomist Carlos Emery. Based on studies of preserved material, he arrived at the conclusion that *Aenictus* might be one of the most archaic dorylines and therefore one closest to the primitive trunk near the ponerines. With time I became increasingly interested in the comparative behavioral importance of the relatively small size of *Aenictus* workers and colonies and monomorphism in the workers.

Investigating the behavior of existing species is a relatively new approach to the study of evolutionary relationships. In contrast with this approach, the taxonomists' classifications derive mainly from the study and comparison of structures in extinct and in existing forms. The approach through behavior study is necessarily the more devious one, for the relationship of structure to behavior is nearly always indirect and involved, and the nature of structural-behavioral relationships still proves highly refractory to investigation. But the behavior of insects (and of other invertebrates) is more closely related to, and more directly influenced by, specific structural characteristics than is that of mammals. From progress already made in discerning the significance of behavioral data for evolutionary relationships in both invertebrates and vertebrates, new approaches along these lines should furnish valuable clues to research and theory. Experience with *Aenictus* has strengthened this interest in evolutionary relationships.

One who encouraged pursuing the *Aenictus* problem was Dr. J. W. Chapman, who studied these and other ants during his long period of service as missionary, biologist, and administrator at Silliman University in Negros Island, southern Philippines. Even during the war, when the Chapmans were forced by the Japanese military (who considered them dangerous) to move high into the mountains west of Dumaguete, Dr. Chapman studied colonies of *Aenictus*, whose activities he thought fitted well the pattern of the *Eciton* cycle as I had described it. Sadly enough—although it was Dr. Chapman's enthusiastic letters about the abundance of *Aenictus* colonies in the Dumaguete area that finally took me there—before either his own monograph on *Aenictus* ecology or our results on the functional cycle could be

**Cleto**, a member of the research group, marks the entrance to an underground bivouac. The ant colony's main raiding trail is shown by string on the right.

**Workers** congregate in laboratory nest. Maturing larvae are in the lower right

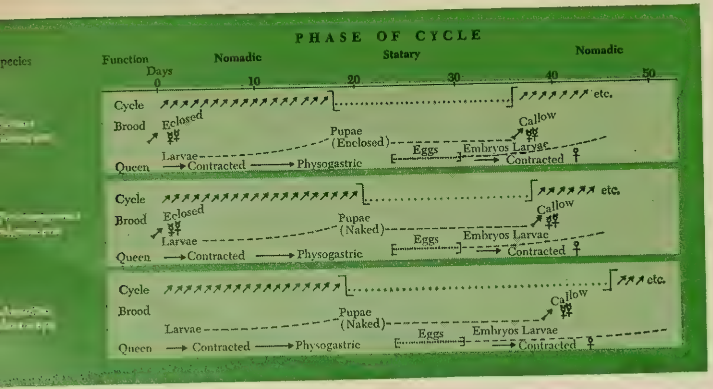
published, he was accidentally killed.

It was the palm-thatched Chapman cottage on the mountain slopes above Dumaguete that, upon his invitation, became the headquarters of our *Aenictus* project when I began it in 1961. Subsequent field investigations have been carried out by an able group of Filipinos directed by my collaborator, Professor Alfredo Reyes, who is with the Silliman University Department of Biology.

At first we worked in the upper forest in an area about 3,000 feet square marked off in co-ordinates for accurately tracing colony movements. By degrees, however, the investigation shifted down to a much larger area that included a plateau of mixed cover and a deep gorge of heavier cover, as new colonies for study were found there. Gradually, also, the daily schedule of research lengthened until it stretched—to meet the *Aenictus* schedule—around the clock.

Doryline activity schedules vary greatly, according to genus and species and to the conditions of the area and the colony. For example, the two surface-adapted *Eciton* species, *E. hamatum* and *E. burchelli,* start their nomadic-phase raids at dawn and build them up during the day. Toward dusk they shift into an emigration that is completed during the night. *N. nigrescens,* of our southern states, less surface-adapted than these *Eciton* species but also a surface raider, generally starts its nomadic raids at dusk and emigrates later in the nightly schedule. These dorylines clearly have quite different daily schedules in the nomadic phase, with the two *Eciton* species day-active in raiding and *N. nigrescens* night-active, although the nomadic raids of all three are long and nearly always end in colony emigrations. These daily nomadic schedules contrast with behavior in the two surface-adapted species of *Aenictus* on which we concentrated. The *Aenictus* colonies, when nomadic, proved capable of raiding or emigrating at any time of day or night, with variations relating mainly to colony condition.

ALTHOUGH at present we can only speculate as to the basis of this generic difference, sensitivity to light is probably the main factor. Most of the New World dorylines, including the E-N group, have small, specialized eyes (lateral ocelli) that cause arousal by light although they play no demonstrable role in orientation. *Aenictus,* whose workers have no eyes at all, reacts to light in tests. Significantly, the surface-adapted species have pale spots in places such as the sides and corners of the head. These may mark the location of subdermal light-sensitive cells. Such spots are absent, however, in other, more subterranean *Aenictus* species, which seem light-shy and in the daytime operate underground or


PHASE OF CYCLE
pecies
Function
Days
Nomadic
Statary
Nomadic
0
10
20
30
40
50
Cycle
etc.
Brood
Eclosed
Pupae (Enclosed)
Callow
Larvae
Eggs
Embryos Larvae
Queen
Contracted
Physogastric
Contracted
Cycle
etc.
Brood
Eclosed
Pupae (Naked)
Callow
Larvae
Eggs
Embryos Larvae
Queen
Contracted
Physogastric
Contracted
Cycle
etc.
Brood
Pupae (Naked)
Callow
Larvae
Eggs
Embryos Larvae
Queen
Contracted
Physogastric
Contracted

**Functional cycles** of three genera show their alternating nomadic and statary phases of behavior. Statary phase ends when new brood appears.

**corner. Excitation by larval broods stimulates more energetic raiding.**

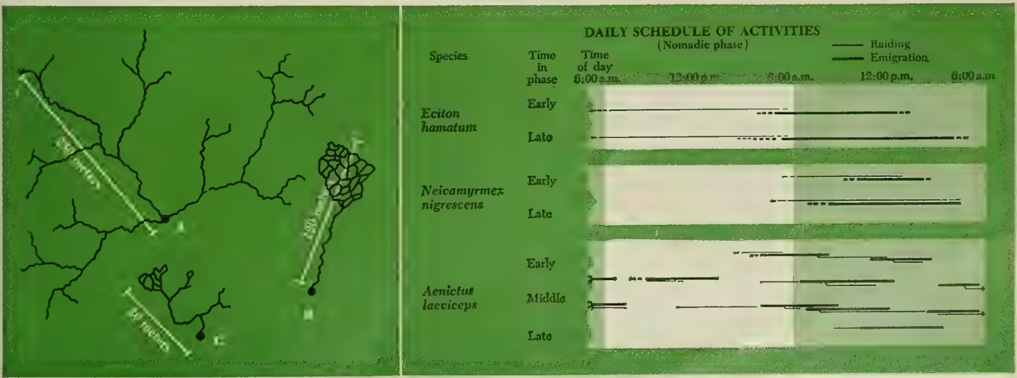
beneath surface cover, unless they are in the dim light of heavy forest. We found that *Aenictus* raids, early in the nomadic phase, begin most frequently toward dusk. On subsequent days, they shift increasingly to morning starts. But throughout most of the phase, paralleling a clearly increasing colony excitement, they can begin at almost any time. A hypersensitivity to light, which inhibits daytime raiding aboveground, may prevail early in the nomadic phase, and may be succeeded in that phase by a condition in which light becomes attractive and daytime surface activity increases as the level of colony excitement rises.

Our studies were concentrated on *Aenictus laeviceps* and *A. gracilis*, the two dominant surface-adapted species in the Dumaguete area. When colonies of these species are nomadic, they commonly raid on the surface even in full daylight. How far surface adaptation has progressed in *A. laeviceps* and *A. gracilis* is shown by the fact that their colonies, when nomadic, usually form their bivouacs on the surface itself—although generally under a light cover, such as leaves—in simple, disk-shaped clusters that enclose the broods and queen. In the last nomadic days, however, a tendency toward underground bivouacking appears, and subterranean (or deeply concealed) sites are the rule in the statary phase. A generic similarity in nesting reactions, dependent upon changing colony condition in the cycle, is indicated by the similar behavior of *E. hamatum* and *E. burchelli*; both shift from exposed surface bivouacs to sheltered sites in late nomadic days and to deep shelter (in hollow logs or trees) to start the statary phase. From our evidence, both *Eciton* and *Aenictus* readily enter more sheltered sites as they become disturbed by such conditions as air currents, higher temperatures, and dryness, typical of the open sites occupied in the nomadic phase.

However, the surface clusters formed by colonies of these *Aenictus* species in the nomadic phase may be considered primitive in comparison with the complex, highly specialized nomadic bivouacs typical of *E. burchelli* and *E. hamatum*. The *Eciton* species are also much more highly specialized than *Aenictus* in their patterns of raiding. The raiding forays of all dorylines are carried out on chemical trails, made as ants in the advance groups enter new terrain and in their excitement deposit body secretions that can be followed by others who, in pressing on, extend the trail similarly in relay fashion.

THE main development of an *Aenictus* raid involves a stage of exodus from the bivouac, in which a heavy column divides and redivides while the raiders accumulate booty in caches at the trail junctions; and then (in the simplest case) a stage of reversed traffic, in which the booty is transported to the bivouac. In more complex cases, successive new outbursts from the bivouac may occur, reinforcing the raid and extending the front, before a lasting reversal of traffic toward the bivouac occurs or the entire colony emigrates over trails formed during the raid. The raiding systems of *Aenictus* are smaller and simpler than the branching systems of *E. hamatum*. Although the nomadic-phase raids of *E. hamatum* last through the entire interval of daylight and often build up to a distance of more than 800 feet, those of *Aenictus* generally last only from part of an hour to a few hours and usually do not extend more than 65 feet.

A simpler and more direct relationship seems to exist between raiding and emigration in *Aenictus* than in the E-N group. *Aenictus* colonies, even when nomadic, often show quiescent intervals at the bivouac during which no ants emerge. These intervals may



**RAIDING PATTERNS of *Eciton hamatum* (A), *Eciton burchelli* (B), and *Aenictus laeviceps* (C) are seen at left. *The Aenictus gracilis* pattern is similar to C. Daily schedules, *above*, compare activities of *Eciton, Neivamyrmex,* and *Aenictus.***

occur at almost any time and last from part of an hour to several hours. But this does not mean that a relatively dormant condition then exists in the colony, as it does in the statary phase. Laboratory observations indicate that these pauses in external activities arise mainly through processes that hold ants within the bivouac, and particularly through worker actions with the brood, such as feeding. External conditions may also play a part, as on hot, bright days when quiescent intervals occur more frequently about midday than at other times. Even *Eciton* species, which never stop their nomadic raids throughout the day, often exhibit a slowdown in the midday period.

The start of a new *Aenictus* raid, after either an emigration or an interval of external quiescence, is marked by the sudden appearance from the bivouac of a few dozen agitated workers that rush back and forth on the trail, their numbers usually increasing rather suddenly. Often this event approaches the magnitude of an explosion of forces in a rushing column or a spreading mass. In the raids of excited nomadic *Aenictus* colonies, the stage of exodus and of dividing and redividing columns is followed by a stage of pillaging, in which networks of columns with variable terminal groups form and re-form as the ants reach a productive area, such as a group of ant nests, then surge on and repeat the process in another area. Often the raiders seem to be following the victims' own chemical trails, as when a column surges directly to the prey's nest from a yard or two away. Many times the prospective victims are aroused in advance by their own foragers that have met the *Aenictus* frontal wave, so that when the raiders arrive, the disturbed occupants are already rushing forth with their brood to scatter and huddle under leaves until all is again quiet. In this way, as well as by defense, in larger colonies the victims may salvage some of their young. It is quite possible that the *Aenictus* become attracted to the species odors of their common victims, and the victims repelled by that of their common enemy, through simple processes of conditioned-response learning.

As inspections of the booty returned to caches or to the bivouac suggest, the victims include a variety of arthropods, both social and solitary, as well as other invertebrates. *Aenictus* booty covers a wide range, even including vegetable matter, with various species of ants and their broods most frequent, but with termites, wasps and their brood, roaches, spiders, beetles, and a host of others also taken. The *Aenictus* are quick, have strong jaws and virulent stings, can usually rush numbers to the scene of a heavy fight, and are not often worsted when the raid issues from an excited nomadic colony. Pulling at a victim from all sides, often in chains of interlocked bodies, *Aenictus* are capable of tearing to bits even the large earthworms they sometimes attack in their underground burrows. Frequent victims among the ants are colonies of tree-nesting *Camponotus* and *Polyrachis*, the latter often succumbing despite the heavy armor and body spines of their workers and the sutured-leaf nests that enclose their broods.

In vigorous raids, *Aenictus* columns regularly mount the lower vegetation and even get high into tall trees, where invasions into the nests of ants and of wasps, such as the large tropical *Ropalida* sp., often prove fruitful. Despite the strong, snapping jaws of the wasps, which crush many of them, the *Aenictus* tear through the paper walls into brood cells from which the young are dragged out together with the huge bodies of those adults that stayed to fight. Such raids may last for hours when vigorous nomadic-phase raids of legionaries strike large colonies of ants or wasps.

An *Aenictus* colony makes a substantial haul of booty on nomadic-phase raids simply by pushing forward its dragnet of dividing and redividing columns over a widening zone. The first raiders to emerge with pieces of booty usually reverse their direction quickly to the rear and are soon on their way to a booty cache or the bivouac. Turning correctly at trail branches is simplified because these branches, through the forward momentum of the initial dividing groups, are likely to be Y-shaped with their bases pointed toward the nest. For the booty-carriers, it is not a matter of knowing where the nest is, but merely a process of following a chemical track and bucking traffic. After a time, however, when outgoing traffic has lessened and the laden traffic has increased, the booty-carriers seem to be aided by a new olfactory cue, and can take the correct (nestward) trail by turning to the side that is saturated with booty odor. This saturation of the trail, as in E-N raids, is caused both by the direct contact of dragged heavy pieces with the ground and by volatilization from lighter, carried pieces.

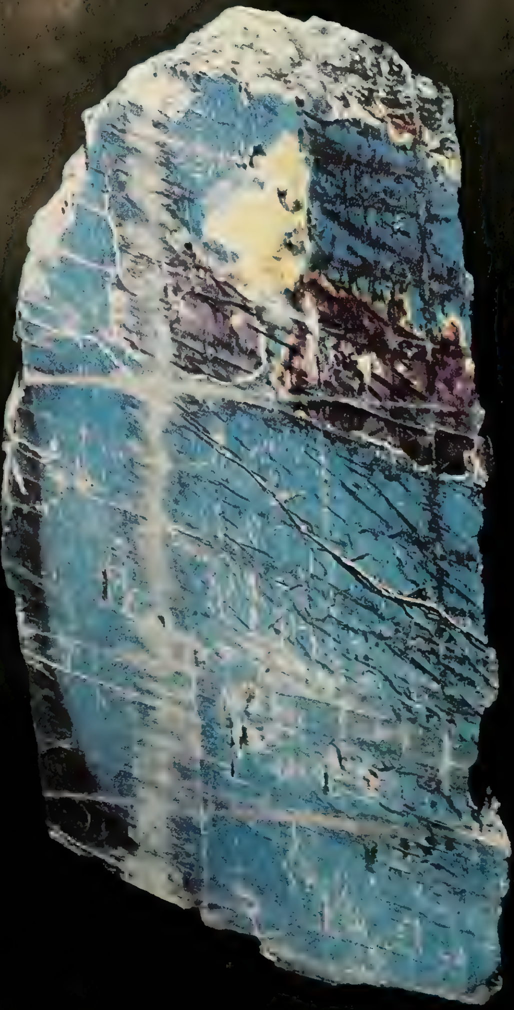
*Aenictus* raids sometimes continue for hours, with the colony collecting thousands of pieces of arthropod booty from the area through which it is passing. This booty, whether returned to the current bivouac or left in caches until carried to the next bivouac in an emigration, is soon consumed by the colony and especially by the brood.

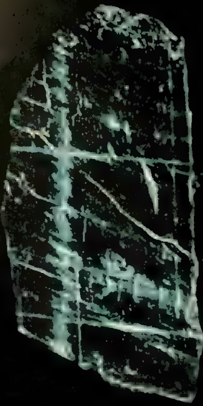
*(To be concluded in November)*

**Posed workers** of *Aenictus laeviceps* attack one of *Polyrachis bihamata.*

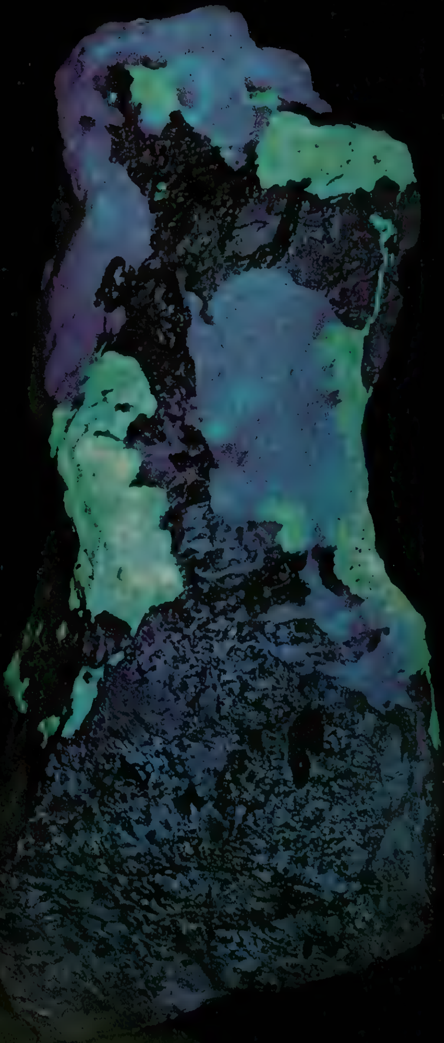
**Colonies of tree-dwelling *Polyrachis* are often victims of *Aenictus* raids.**

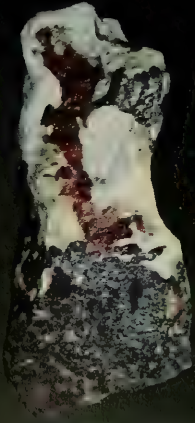
**Colony of *Aenictus* emigrates to new bivouac. Each worker carries a larva.**





Labradorite, of the plagioclase feldspar series, is shown under white light with interference, *far left*, and at non-interfering angl





Specimen of willemite, calcite, zincite, and franklinite is shown under white light. To its right is same specimen under ultraviolet.

# Interaction Between Light and Minerals

## by PAUL E. DESAUTELS

LIGHT, as it incessantly probes its way about the universe, is more appreciated by man for what it does than for what it is. One thing it does is to react in some way with every object it touches. Through common usage, the term "light" has come to mean "visible light," even though the visible portion is only an extremely small part of a kind of energy known as electromagnetic radiation. Such apparently diverse kinds of emanation as X-rays, ultraviolet rays, green rays, red rays, heat rays, and even radio waves are really only different degrees of the same kind of radiation. These differences in degree are usually labeled as differences in wavelength. Wavelengths visible to the human eye are generally considered, for all practical purposes, to have lengths in the range between 4,000 and 7,000 Ångström units. (One Ångström unit is one ten-millionth of a millimeter.)

The reaction between visible light waves and certain minerals produces a number of phenomenal and often beautiful or exotic effects. Some of the best-known of these effects are asterism and chatoyancy, schiller, labradorescence, opalescence, fluorescence, and fire. In mineralogical texts there is a tendency to avoid explaining these phenomena, primarily because their description contributes little to an understanding of the science of mineralogy. Texts in physics generally ignore them because they are only "practical examples" of phenomena that are better illustrated in some other fashion. Perhaps the scarcity of understandable information has only served to stimulate more interest.

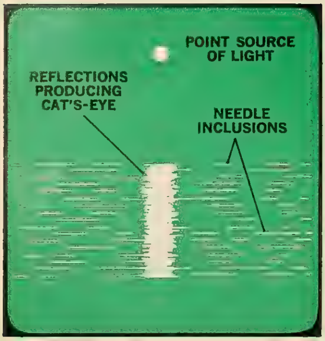
Since several of the effects mentioned involve manifestations of color, it might be fitting to review briefly the nature of color in minerals. The color of a solid object depends mainly upon its innate ability to absorb, transmit, and reflect—in a selective way—the collection of wavelengths composing "white" light. Quite simply, absorbed wavelengths are lost to the observer unless they are absorbed, processed, and later returned. Transmitted wavelengths, traveling through a solid object, are also lost unless the object is placed between the light source and the observer. Usually, it is the reflected wavelengths, which are bounced back to the eye of the observer, that are translated by him as color. This color is usually a blend of colors with the hue or kind depending upon the wavelengths received.

A mineral is said to be idiochromatic if its own composition and structure are responsible for the wavelengths that are reflected. Thus, cinnabar—mercuric sulphide—is always red because it is mercuric sulphide of a particular atomic structure. Azurite—a basic copper carbonate—is also idiochromatic and is blue because it is a copper carbonate of a particular atomic structure. A quite similar chemical compound with a different atomic arrangement is green. Should the color of a mineral depend instead upon the presence of trace amounts of impurities or minute imperfections in its structure, that mineral is said to be allochromatic. Thus, beryl, an allochromatic species, is colorless when pure, but traces of chromium cause it to be bright green, and then it is called emerald. If it has traces of iron, it becomes the sea-green aquamarine. Both idiochromatic and allochromatic colors are caused by the interaction between light and some of the electrons that are part of the atoms that compose the mineral. Atoms whose electrons commonly cause color in solids are usually of the group of elements called transition elements. These include copper, iron, manganese, chromium, nickel, cobalt, vanadium, and titanium. The light energy absorbed by these electrons is not destroyed (a physical impossibility) but is normally converted to some longer wavelength, such as that of heat.

In addition to the ordinary color of residual unabsorbed wavelengths, there are certain other color effects that are unrelated to the chemical composition of the mineral and are purely physical effects caused by gross impurities and structural aberrations. The physical process producing one of these effects is called interference.

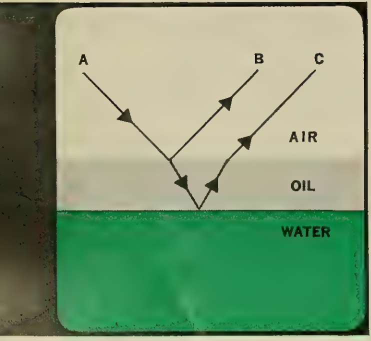
Interference colors are usually explained by invoking images of thin films, such as an oil slick on a rain-wet street. A ray of light (A) strikes the thin layer of oil at some angle (*diagram, page 54*). Some of the ray is reflected immediately (B). Some of it penetrates the film and, in turn, is reflected from the contact surface between the oil and water. This second portion (C) traveling back through the oil film continues on its way parallel to the first ray fraction. However, it is retarded because it has traveled a longer distance. This means that the light waves, in the two parts bouncing back, have gotten out of step with each other. Since light waves are additive (and subtractive), the resulting combination of the two wave portions (B and C) in the eye of the observer is of a different mixture of wavelengths from the original ray (A) or, by definition, a different color blend. The hue produced by these interfering wavelengths depends upon the thickness of the oil film and the angle of light incidence, since these determine the extra travel distance of the second fraction and thus the amount of its retardation. If the film is too thick or too thin, interference effects are lost.

The beautiful blue glow, or schiller, exhibited by peristerite is caused by interference. In this case the "thin films" are thin plates (lamellae) of which this plagioclase (from the Greek words *plagios*, oblique + *klasis*, a

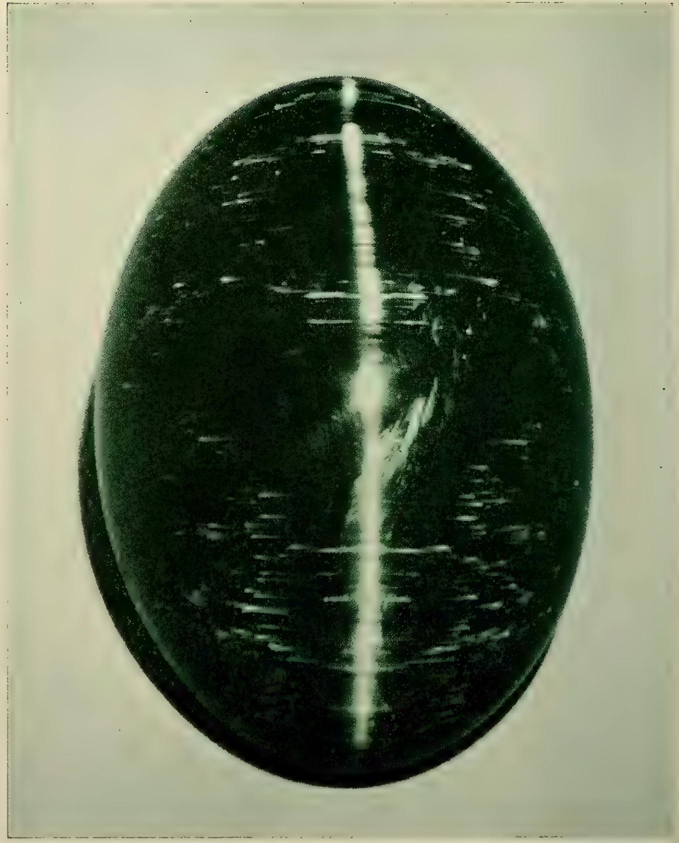


Light band is composed of myriad point reflections from needle inclusions.

breaking) feldspar mineral is formed. One of the characteristics of plagioclase (soda lime, $NaA1Si_30_8$—$CaA1_2Si_20_8$) feldspars is the layering caused by repeated crystal twinning. Twinning is a common phenomenon in mineral structures. It involves a change in direction of the orderly arrangement of atomic units that compose the structure of the mineral. The arrangement of the plagioclase feldspar structure alternates its direction frequently during the growth of the mass (*diagram, page 55*). When the twin lamellae are thin enough, they behave as thin films and thus produce interference. Moonstone, which is orthoclase (potash, $KA1Si_30_8$) feldspar, also owes its color to interference. This variety of orthoclase occurs in thin layers interlaminated with albite, one of the plagioclase feldspars. If the layers are thin enough, the blue glow of moonstone results.



Hue is determined by thickness of oil layer and angle of light incidence.



Cat's-eye gem shows chatoyancy, or a distinct band of reflected light.

Interference, too, is responsible for the play of colors sometimes seen on the surfaces of lightly tarnished metal objects. The layer of tarnish acts as a thin film with the usual effects. A copper mineral, bornite ($Cu_5FeS_4$), tarnishes quickly on freshly broken surfaces and, as a result, develops a display of interference colors rich in reddish-purple hues. Its common name of peacock ore is well chosen.

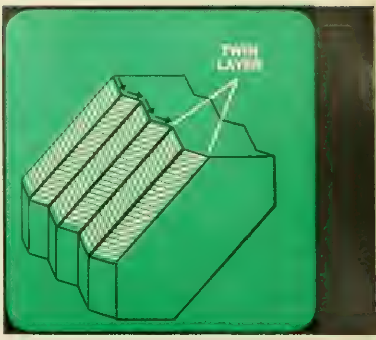
In some samples of plagioclase feldspar there are innumerable inclusions of microscopic plates of goethite or hematite. These plates, often red-orange, are well scattered in the almost colorless feldspar, but are in parallel orientation. This orientation was caused by atomic forces interacting between the inclusions and the host mineral at the time of its formation. As light penetrates the feldspar, it is reflected from myriads of these tiny, flat inclusions at the same instant, and the stone lights up with a cloud of brilliant, reflecting pinpoints. Such feldspar, usually the oligoclase variety of plagioclase, is fittingly named sunstone, or aventurine. The phenomenon differs from interference because it is produced purely by the reflection of light. Other mineral species, of course, can be aventurescent. For example, a variety of quartz that contains tiny reflecting plates, usually of mica, is also called aventurine.

As might be expected, since interference and aventurescence effects are both found in plagioclase feldspars, the two phenomena may occur in the same specimen. Labradorescence, named for its appearance in a calcium-rich plagioclase feldspar called labradorite, shows as large patches of iridescent blue and green color with occasional reds and yellows. Most of the effect is due to light interference caused by the thin lamellae that result from typical plagioclase twinning. Some of the color flashes, however, are caused by the reflection of light from numberless platelets of black magnetite, which are arranged as parallel inclusions. If the portion of labradorite through which such an array of platelets reflects light is thin enough, interference occurs and the reflections assume color. Sometimes, when the feldspar through which these reflections travel is too thick, there is no interference effect, and the reflections appear as bright spots of aventurescent light superimposed on the iridescent interference color normal to the labradorite. In labradorite, too, the magnetite plates give the mineral a dark-gray to black color, which is ideally suited as a background for the rich display of iridescent, usually blue or green, colors. Labradorescence, then, is a combined light effect.

CHATOYANCY refers to the single, slitlike band of light—like the eye of a cat—reflected from certain oval, cabochon-cut gemstones. Asterism is the starlike reflection so well known in star rubies and star sapphires. The two effects of chatoyancy and asterism are modifications of the same phenomenon. Some mineral specimens contain inclusions of needle-shaped reflecting bodies of other species such as rutile. These inclusions may even be hollow tubes. A combined reflection phenomenon is produced when the tubes or needles are oriented in parallel bundles. Singly, the inclusions are too small to produce much of an effect, but in numbers the effect is reinforced and becomes a prominent feature. If there are too few inclusions, the reflection is either weak or, perhaps, totally ineffective. The orientation of the needles is parallel to one or more directions that are related to the internal atomic structure of the mineral. Chrysoberyl and tourmaline are two species that frequently contain oriented, needle-like inclusions in a single crystal direction. When exposed to a point source of light, each needle reflects the point, and the reflections align themselves to produce a cat's-eye. By cutting such stones as oval or circular domes the gem cutter assures the resemblance to a cat's eye. Chrysoberyl cat's-eyes of good color and with excellent chatoyancy are valuable gemstones.

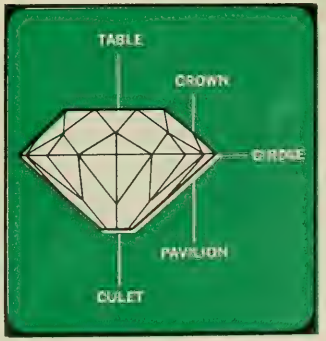
In crystals of corundum—and a limited number of other species—there are sometimes more than one set of needles. These sets arrange themselves in corundum in three different directions—120° apart but in the same plane. The directions are parallel to possible crystal faces (*drawing, page 57*). Instead of one band of light reflections there are now three bands which intersect at a common point. The effect is a bright star of light that is especially well defined when the fragment is cut as a domed cabochon with the ray intersection directly at the center of the dome. The curvature of the cut stone must also be carefully controlled so that the legs of the star are not crooked.

The term opalescence is so frequently misused to describe the fire of precious opal that there seems to be little hope of returning it to its proper meaning. Actually, the word refers to the bluish-milky appearance of common opal and of some moonstone. Under this heading, however, it seems appropriate to discuss the light effects produced in both common and precious opal.

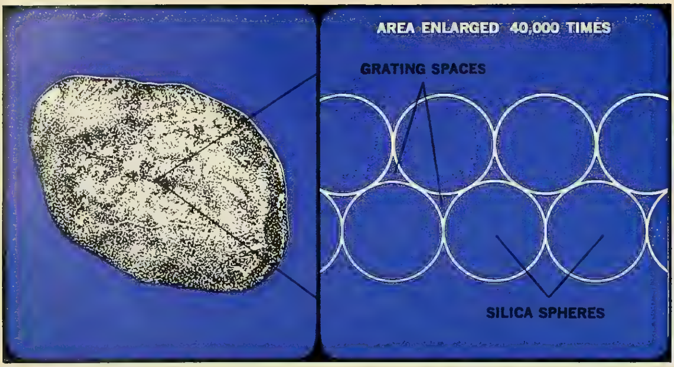


Twinning is caused by direction change in arrangement of the atomic units.

The peacock play of colors in precious opal has long resisted explanation. It would almost seem as if there have been as many theories advanced as there are colors in the stone. Some speculation has come surprisingly close to the recently determined facts. Electron microscope photographs of both precious opal and common opal have been taken at extreme magnification (up to × 40,000). In these photographs, precious opal is seen to consist of layer upon layer of spheres of silica (silicon dioxide, $SiO_2$) arranged row upon row in neat, orderly patterns with relatively uniform spacings between the spheres (*drawing, page 56*). Light rays that strike the surface of precious opal are subject to a remarkable optical phenomenon known as diffraction. Precious opal, with its orderly network of silica spheres, performs exactly as an optical device known as a diffraction grating, which consists of a series of parallel lines scratched on a polished glass or metal plate (as many as 30,000 lines to an inch) with a fine diamond point. Portions of a light beam directed at such a grating are reflected back from each of the thousands of still-polished gaps between the scratched lines. Using just one of these tiny "beamlets" as an example, the part that is closest to the edge of the neighboring scratch is bent from its expected path. This bent, or diffracted, portion is now thrown out of phase with the rest of the beamlet and is in a position to cause interference with its neighboring light waves. The behavior of this single tiny reflection is repeated by all the thousands of others from the rest of the grating. Since the diffraction is consistent all across the grating, provided that the grating is uniformly made, the interference is also uniform, and the color it produces is uniformly visible over the entire grating. Precious opal shows its diffraction colors in patches. This is only because the orderly arrangement of silica spheres occurs in irregular patches, and the patches are not necessarily oriented in the same direction. The thickness and spacing of the scratched lines of a diffraction grating have a direct effect on the interference colors produced.



Brilliant cut is standard cutting style where high dispersion is desired.



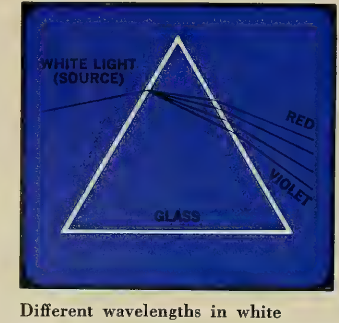
**Precious opal is composed of layers of silica spheres in orderly rows.**

The relative positions of the light source, the grating, and the observer also help to determine the colors. So it is with opal. Size and spacing of the silica spheres and relative positions of light, opal, and observer make striking differences in the color observed.

In contrast, common opal, which is composed of the same kind of silica spheres, lacks the orderly arrangement, so light striking it cannot be diffracted but is only scattered. Such scattering of light, producing the typical bluish-milky appearance, is well known to physicists as the Tyndall effect. It is usually demonstrated by passing a light beam through water that contains a suspension of tiny droplets of oil or particles of some other insoluble substance and observing the scatter. (Sunlight, especially the blue wavelengths, traversing the dust- and moisture-laden atmosphere of the earth, is also scattered, giving us milky-blue skies. Shorter blue wavelengths are more easily scattered than the longer red ones.) When a piece of common opal is observed by looking through it at a light source, it assumes a strong reddish-orange body color. All the blue wavelengths have been scattered, and only the red wavelengths have made their way through to the observer.

Other samples of opal are neither precious nor milky in appearance. Electron microscope photographs furnish a plausible explanation for this. Opals grow as tiny concentric spheres by the deposition of silica on a nucleus held in suspension in water. Later, by a kind of natural filtering process, the spheres are concentrated, deposited, and cemented together by additional silica. If the cementing silica is excessive and fills the orderly ranks of spaces between the spheres, the resulting opal remains transparent because of its orderly internal structure, but with the spaces gone it can no longer act as a diffraction grating. If cementing silica is sufficient to hold the spheres together but still leaves the holes comparatively open, the opal will be precious and full of fire if its arrangement is orderly. It will be common if its arrangement is disordered.

One of the prime laws governing the behavior of light—one stressed in every high school physics course—concerns the bending of light as it travels from one substance to another. The amount of bending, or refraction, depends upon the nature of the substances themselves. What is not stressed as strongly is that the different wavelengths that comprise white light are not all bent to the same degree. The longer red wavelengths are bent least and the shorter violet wavelengths are bent most. A beam of white light, then, may be spread out by refraction into its separate constituent colors. This is known as dispersion. If the surfaces of the dispersing material are arranged to prevent regrouping of the wavelengths, the color separation becomes permanent and visible.



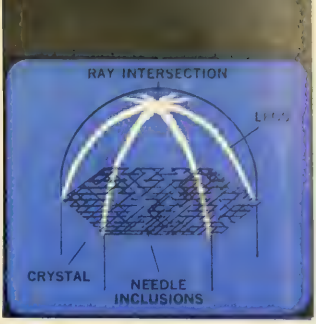
**Different wavelengths in white light are not all bent to same degree.**

Some minerals have a strong dispersive effect on white light. Diamond and zircon are good examples. By proper cutting, gemstones are fashioned that take advantage of the effect. With a diamond, for example, the facets are so arranged that most of the light entering through the top (table) of the gem is reflected internally and returned through the top of the stone as brilliant flashes. At the same time, since the back (pavilion) facets are inclined to the top (crown and table) facets, color dispersion shows as red, yellow, blue, and other colors of fire. Certainly this color display accounts, at least in part, for the popularity of diamonds. The superior dispersion of transparent crystalline zircon also explains its use as a diamond substitute.

The phenomena previously decribed have all been the result of reaction between solid objects and visible, or white, light. This does not imply in any way that there are no visible reactions between these solids and the non-visible wavelengths of light. One of the more spectacular of such reactions is called fluorescence. The term comes from the name of a mineral species, fluorite, in which the effect is sometimes observed as a brilliant glow of color.

Some substances have the ability to absorb wavelengths just beyond the visible range in the ultraviolet regions of the light spectrum. In such substances the absorbed radiation is accumulated by electrons in the atoms of the solid. These atoms may belong to the substance itself or to its impurities, called activators. The activator in fluorescent willemite (zinc silicate) and calcite (calcium carbonate) from Franklin, New Jersey, is a small amount of manganese present as an impurity. Too much manganese or the presence of a small amount of iron in these same samples dampens or eliminates the fluorescence. Temporarily, when fluorescence occurs, the electrons excited by the ultraviolet energy move into new relationships with the nuclei of their atoms because of their increased energy content. There is a strong tendency, then, for these electrons to give up the extra energy and return to their former stable positions. By their very nature, the electrons can emit energy only at characteristic wavelengths that may have little to do with those absorbed. According to Stokes' law, whatever the absorbed wavelength, the emitted wavelength is longer. Thus, the absorbed, short wavelength of invisible ultraviolet, just beyond the short-wave end of the spectrum, is returned by the excited electrons as visible longer wavelengths of blue, green, red, or other colors. The invisible has become visible.

Several types of commercially available lamps can be used as sources of ultraviolet light to demonstrate fluorescence. Almost all of these supply ultraviolet wavelengths of either 2,537 (short wave) or 3,650 (long wave) Ångström units. Because fluorescent substances are diverse in their characteristic wavelength absorption, some of them will fluoresce under long wave, others under short wave, and still others under both these ultraviolet wavelengths.



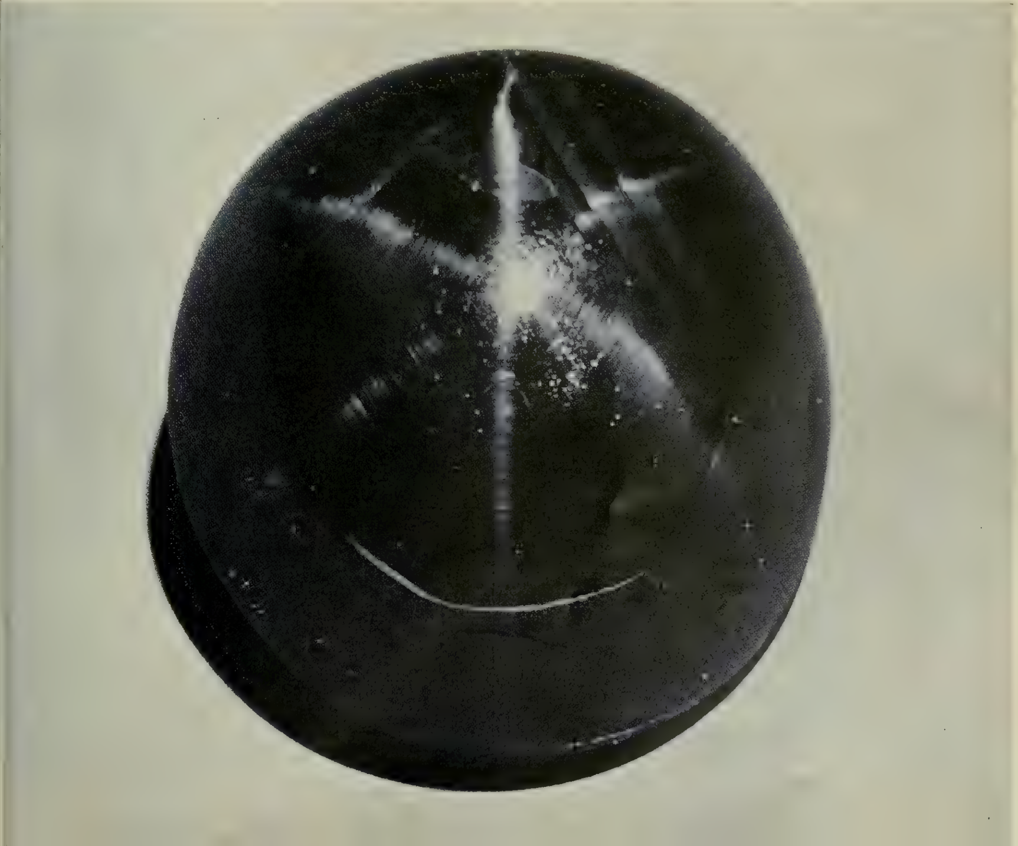
Corundum needles are in parallel planes but arranged in three directions.

Sometimes re-emission of the absorbed light is delayed as energy-excited electrons become trapped in semistable positions. In this case, after the exciting source of ultraviolet is removed, emission continues over a period of time at a diminishing rate until all the electrons have returned to their base positions. This continuing, unstimulated light emission is called phosphorescence.

The foregoing discussion has by no means exhausted the many and varied effects produced by the interaction of light and solids. Nothing has been said, for example, about the strange glow—best observed in total darkness—made by rubbing two pieces of agate together. Nothing has been said about the peculiar luster typical of a fine quality pearl. Even the phenomenon of refraction has only been touched lightly, and an entire science of optical crystallography has been built on this characteristic alone. In short, the whole subject of interaction between electromagnetic radiation, including visible light, encompasses much of the sciences of physics and mineralogy.

Totally aside from the scientific implications of the phenomena discussed here, the aesthetic values are obvious.

Reflection phenomenon known as asterism is seen in this star sapphire.



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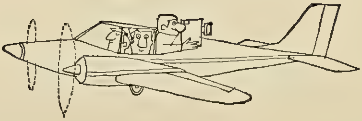

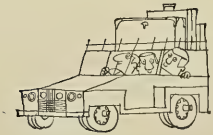

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# About the Authors

Dr. Fernando Dias de Avila-Pires, author of "The Floating Community of Amazonas," is a mammalogist at the Museu Nacional in Rio de Janeiro, Brazil, and is a Research Associate at The American Museum. His special field of research is Neotropical mammalogy, especially rodents and primates.

"Master Goldsmiths of Sitio Conte" is taken from the book *Sweat of the Sun and Tears of the Moon*, written by André Emmerich. The book, published recently by the University of Washington Press, deals with the use of gold and silver in pre-Columbian art. Mr. Emmerich is an art dealer in New York City, specializing in contemporary painting and sculpture and archeological art. Another of his books, *Art Before Columbus*, was published in 1963 by Simon & Schuster.

The article on the Musk Duck is the work of Dr. Paul A. Johnsgard, Associate Professor of Zoology at the University of Nebraska. Dr. Johnsgard received his Ph.D. from Cornell University in 1959, after which he spent two years in England making comparative behavioral studies on the family Anatidae—ducks, geese, and swans. He has also studied the Spectacled Eider in Alaska, the Musk Duck in Australia, and the Torrent Duck in South America.

Dr. Sherwin Carlquist, author of "Rare Cypress Clings to Coast Habitat," is Associate Professor of Botany at Claremont Graduate School and an honorary research associate of the Rancho Santa Ana Botanic Garden, Claremont, California. He has written many papers on plant anatomy and morphology, and a book, *Comparative Plant Anatomy*. Another book, *Island Life*, on the natural history of islands, will be published next month by Natural History Press.

"Dorylines: Raiding and in Bivouac" is Part I of a two-part article by Dr. T.C. Schneirla, Curator of the Department of Animal Behavior at The American Museum. His special research interests include mammalian behavioral development and learning, orientation and communication in ants, insect learning and instinct, and a study of the problems in the comparative psychology of learning.

Paul E. Desautels, author of "Interaction Between Light and Minerals," is Associate Curator-in-Charge of the Division of Mineralogy, Department of Mineral Sciences, Smithsonian Institution, United States National Museum. He holds a B.S. and M.S. from the University of Pennsylvania, and was Professor of Chemistry at Towson College in Baltimore before joining the Smithsonian eight years ago. He has studied and collected minerals for many years, and is the author of a new guide to the national collection of gems.

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# Confessions of a curator

### By Sydney Anderson

Most people have heard of curators, and are vaguely aware that they are kept in museums. Exactly why they are there is known by few, and I suppose even a curator occasionally wonders about this. Most of us are very familiar with the question "What do you do?" after we have identified ourselves as curators. Sometimes the query reflects the same wonderment evoked by a strange, new, and unknown species.

The thesis of this article is that what curators do is important, and that curators, as well as curious laymen, should ponder the question, "what does a curator do?" Now, a curator is engaged basically in producing and/or distributing knowledge, depending on the policy of the institution with which he is associated. But what sort of knowledge does he produce? How does he produce it? How, and to whom, is it distributed? Could this same knowledge be produced in some other manner, or in some more efficient manner? What are some of the actual tasks of a curator and how are these related to the basic objectives? And, to get down to day-by-day decisions, when several things must be done, what should be done first? How much time should be devoted to what?

These questions apply to all museums, whether they are oriented to history, art, natural history, or some other field, but my discussion here pertains chiefly to museums that regard research as one of their purposes, and that have natural history as their central field of interest.

## Research Activities

First of all, the curator is a scientist. The current literature received each week at the museum library may occupy six feet of shelf space. Although only a few hundred pages may be of interest to any one specialist, all these pertinent books and articles must be scanned or read and often recorded on reference cards. The Department of Mammalogy at The American Museum maintains a file of more than seventy thousand cards referring to publications in the field of mammalogy. This file is used by staff members, visiting scientists, authors, amateur naturalists, reference services, and students.

Scientists also keep informed by talking with other scientists who visit the museum to study specimens, use the library, or attend meetings. Usually, one or more visiting scientists are at work in the Department of Mammalogy. The average scientist attends at least one or two national or international meetings of professional societies each year, in addition to the more frequent local society meetings. At these functions he reports his own activities and discoveries—by presenting formal papers and by informal discussion—and he learns what others are doing. These exchanges help maintain a professional awareness that is essential to the basic task of research—the discovery of knowledge. This awareness helps focus attention on areas needing study, on new techniques that may be helpful, and on discoveries in related areas. It also minimizes the chance that effort will be spent in solving a problem that has already been solved or is being investigated.

The special interests of the investigator determine what subjects are studied. A curator will tend to work on problems that he is specially qualified to solve by virtue of his having access to museum collections. This helps to assure the most efficient use of museum facilities, but does not mean that other problems are less worthy of study. The curator whose interests lie in the broad and eclectic field of systematic biology, for instance, welcomes sound, comparative evidence from every field, whether it be biochemistry, genetics, animal behavior, electron-microscopy, statistics, or ecology. In turn, knowledgeable workers in these and other fields eventually look to the curator for answers to such questions as: What is this animal in which I have discovered rabies? What seem to be the relationships between these different animals whose nerve endings I have studied? What species are most likely to be of greatest use in a comparative study of the blood proteins and diet? What does this animal, which has an amazing ability to produce high-frequency sounds, actually do in nature? How can we explain the origin and maintenance of a certain biochemical process that influences development?

Because of his interest in field work and in specimens, the curator will himself ask many questions: What kinds of animals (or plants or minerals) occur in what parts of the world? What are the different kinds of animals and how may they be recognized? What variation occurs in each species from one place to another? How are the males different from females? How can young or larvae be recognized? What do they eat? What sort of place do they inhabit? Do they build nests? Do they have parasites? Do they have diseases? Do their teeth decay? How many are there in a square mile? Do they migrate? How often do they grow new hair (or feathers or leaves)? How big do they get? And each answer raises a new question.

The most efficient way of obtaining answers to many questions lies in the study of museum specimens. For example, to learn the geographic distribution of a certain species of animal not easily observed or identified in the field—and this includes most animals—a curator studies specimens. He verifies the identification of each and puts on a map the exact locality of capture from among the various data on each specimen's label. Eventually, if enough collecting has been done, one has a reasonably accurate knowledge of the animal's distribution, and anyone who has doubts can examine the specimens.

This element of verifiability is important in science. Just as the materials and methods used in any experiment must be explicitly stated so that the experiment is repeatable and thereby verifiable, the materials used by the museum naturalist are noted and preserved for future study and as a means of verification. If someone tells me that he saw a hairy-nosed wombat loose in Central Park, the observation needs substantiation and I am somewhat skeptical (at least until I call the zoo and learn that one has escaped). But if someone brings in a specimen of a hairy-nosed wombat, and the fact that he found it in Central Park is beyond reasonable suspicion, the observation can be affirmed, although the question of how the creature got there remains unanswered. And, if the specimen is preserved in a museum, the observation can be verified one hundred years from now.

The essence of human culture in general, and that part of human culture known as science in particular, is that each generation can build on what has been done before. The task of a scientist is not finished when he has discovered the answer to his question, but only when he has reported or published his discoveries so they can be used by others. The organizing of material, writing and rewriting, typing and retyping, checking and rechecking of figures and bibliographic sources, preparing of illustrations and graphs, reading of galley proof and page proof, and distributing reprints all require time and effort on the part of the curator, his secretary, artists, and other staff members.

## The Keeping of Collections

A curator is, literally, one who cares for something, and the keeping of collections is one of his best-known activities. It is probably true that a subclinical obsession for collecting things and for some sort of order contributes to the happiness of a curator. He needs

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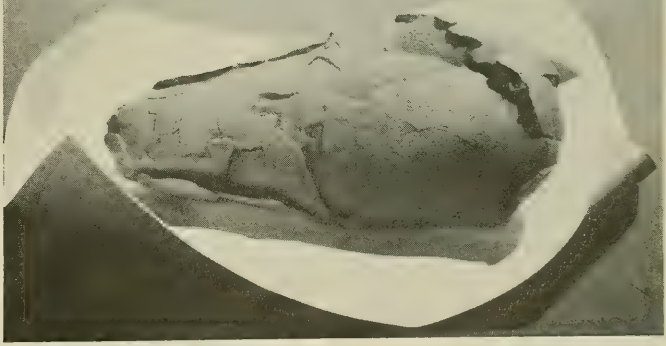

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to find aesthetic pleasure in reducing the entropy that tends to accumulate in collections, as well as in the universe at large. In a well-curated collection, any specimen can be located in a few minutes. If a collection consists only of a few dozen specimens, no special arrangement may be needed beyond keeping them all in one place. When the collection grows (there are more than two hundred thousand mammals in The American Museum of Natural History, for example), some system is necessary. The formulation and actual practice of an efficient system require careful study. Problems of cost, space, preservation, accessibility, simplicity, uniformity, and the amazing diversity of natural objects themselves, whether mammals or cultural artifacts, all must be considered.

Specimens contribute to human knowledge only after they have been studied. The value of a research collection lies in the information it contains, and the value of the curatorial system lies in the ease with which that information can be retrieved. Each field has its own techniques, and I will not detail the twenty-five things you have to do to each specimen of mammal *after* it arrives at the museum and *before* it is available for study. The preparation and preservation of specimens are curatorial tasks in the most literal sense, and they must precede any research that is undertaken.

## Field Work

Research is done in the field as well as in the museum. Specimens come from the field. What the field naturalist is collecting is really information about animals. Specimens without adequate data are usually of little value, and specimens from collections made by some students and unscrupulous professional collectors are worse than worthless because they may be falsely labeled. Data must be recorded on labels with the specimens, in notebooks, in photographs, on magnetic tape, and in other ways. These data are as important as the specimens themselves, and should be obtained, recorded, and preserved with the same care as the specimens.

Preparations for field work begin far in advance of an expedition, and after the work in the field is completed, packing, shipping, matching and checking, cataloguing, and other work remain to be done. Curators are called upon to provide information on materials for others who are afield or going afield. These persons range from serious and competent naturalists of varying degrees of experience to casually interested travelers. Sometimes the services given to these persons by curators eventually benefit the museum in particular or science in general; at other times, except for potential good will, neither the curator, the museum, nor science benefits.

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Field work done by a curator or aided by him may be in his own back yard or in the upper Amazon Valley, but the basic objectives are the same—to add to human knowledge.

Most people think of exhibition halls when they think of museums. Exhibits are one of the most important and characteristic means used by museums to distribute knowledge. It is not necessary to hang a sign over the door saying "These exhibits are educational." In fact, this would be undesirable, because some visitors, who might learn something and thereby profit from the exhibits, are overawed by, or averse to, education as such, and could be frightened away. Artistry and psychological insight, in addition to technical skill and scientific supervision, are needed to prepare adequate exhibits. These should be attractive, concordant, and within the scope of the museum's interests. Again, their basic function is to convey knowledge. I use the word knowledge in a broad, humanistic sense, referring not merely to the accumulation of recallable facts in some person's brain, but also to an awareness of the cultural and natural milieu of man now and in the past. An effective exhibit hall should prove of value to persons of different ages, prior experiences, and interests. The curator's part in the creation of an exhibit is varied. He may initiate or plan individual exhibits or entire halls, and assist in obtaining needed materials and information from the field. He may also participate in the actual construction of the exhibit, and he will certainly check at various stages for the appropriateness and accuracy of all its parts.

## Administration

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DR. ANDERSON is Associate Curator in the Department of Mammalogy at THE AMERICAN MUSEUM. Systematics and biology of mammals are among his principal scientific research areas.

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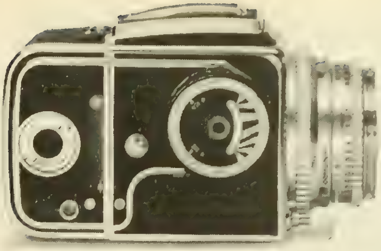
## Public Services

CURATORS perform many public services, but they are not able to comply with all requests. For example, it is necessary to tell some high school students that they must prepare their own science projects. Telephone calls regularly bring questions about the gestation period of an elephant, the size of the largest polar bear, the weight of the largest whale, or some other equally "crucial" question. Medical doctors, public health officials, and inspectors from the Better Business Bureau request identifications of specimens needed in their studies. People bring in bones from excavations or seashores. Those who have heard that there is big money in ambergris bring in various objects (rarely ambergris) they have found on a beach. Occasionally people call asking if the museum will buy their two-headed kitten (the answer is no), or whether the curator would come and get the bat they found in the yard. The curator, ever-mindful of the public interest, attempts to assist these persons who turn to the museum for help or information. Sometimes the question may be answered cursorily; sometimes the questioner is referred to certain books, articles, or other sources of information; some questions have no known answers; and sometimes the curator becomes involved in a problem requiring days of work.

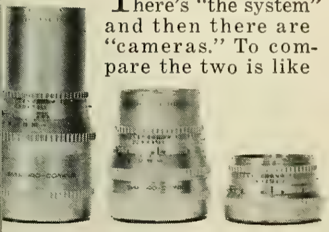
Newspaper reporters, fact-checkers for publishers, authors of children's books, and editors for atlases or encyclopedias all call. There are manuscripts and illustrations that must be checked for accuracy, for organization, or for emphasis. A lawyer calls because a client has been bitten by a dog of a certain breed, or has refused to pay for an exotic animal that was not what he thought he ordered. Non-technical, interpretive, or popular articles and books must be written. Interviews for radio, television, or newspapers are requested. Endorsements may even be sought. Service clubs, school groups, scout groups, and other organizations want programs or special assistance in certain projects. Photographers and advertisers want materials for temporary use.

Which, boiled down, causes a reframing of that question in the first paragraph to, "What *doesn't* a curator do?"



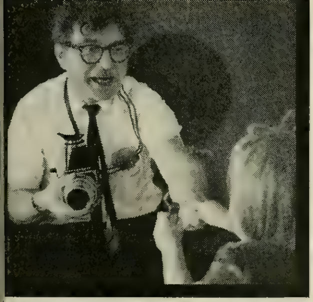
# When you talk about “the system” there’s no brand X to compare it with.

There’s “the system” and then there are “cameras.” To compare the two is like



eft to right: *Zeiss 250mm, 150mm, and 0mm lenses.*

nixing apples and oranges. And ertainly does “the system” an inustice. Because “the system” is nore than a camera. It’s a unique nd complete combination of nterchangeable components that ffers more versatility, more optial excellence than anything alled “camera.”

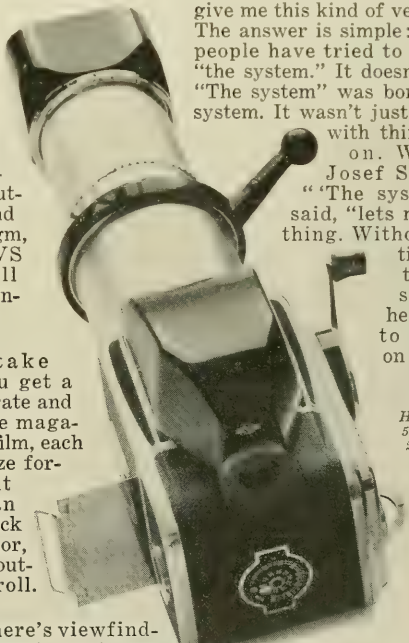


*osef A. Schneider, internationally famous hotographer of children, was introduced Hasselblad while taking a portrait of e Crown Prince of Sweden 15 years ago. e holds the unique distinction of being e first American photographer to use he system” commercially.*

In the area of lenses, for example. “The system” doesn’t have one or two or even three. The number is six. 50, 80, 120, 150, 250 and 500mm. Each one is precision-crafted Zeiss. Each has a Synchro-Compur shutter, automatic and manual diaphragm, and coupled EVS system. And all are completely interchangeable.

Now take film backs. You get a choice of 4 separate and interchangeable magazines. 3 for roll film, each in a different size format, one for cut film. So you can change from black and white to color, from indoor to outdoor film mid-roll.

Then there’s viewfinders. We don’t expect you to see every shot the same way. Your needs change, right? So do our viewfinders. “The system” gives you five. (Four more than you get on most “cameras.”) Eye-level prisms, sportsviewers, magnifying hoods. And sunshades, filters, proxars, bellows, exposure meters, cases. You name it.



*Hasselblad 500C with 250mm lens, fast winding handle, eye-level prism finder, focusing handle and sunshade.*

Now you might say, “Aren’t there any cameras that give me this kind of versatility?” The answer is simple: No. Sure, people have tried to duplicate “the system.” It doesn’t happen. “The system” was born to be a system. It wasn’t just a camera with things added on. We asked Josef Schneider. “ ‘The system’,” he said, “lets me do anything. Without limitation. I know that what I see in my head is going to come out on the film.”

Now you know what we mean by “the system.” Know it well. This is “the system,” not to be confused with a “camera.” For literature, write your dealer or Paillard Incorporated, 1900 Lower Road, Linden, N.J.

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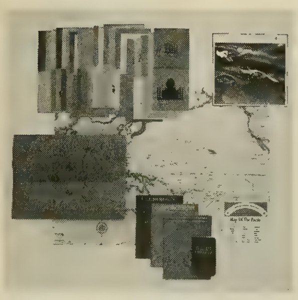

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*FILMS IN REVIEW*

# Decade of improvement

*By Linda S. Gordon*

As part of the trend toward better educational aids, it is not surprising that the quality of science films has improved greatly within the last decade. Those film producers who have not yet perfected their methods will have to compete with quality subject matter, modern photographic techniques, and well-written scripts. Presentations at almost every major scientific meeting are supplemented by films, and many smaller conferences are also beginning to feature them. The American Association for the Advancement of Science, at its 131st annual conference last December, presented sixty of the latest domestic and foreign scientific films throughout the conference period. In September, 1964, scientists as well as educators from many countries of the world met in Athens, Greece, for the Congress of the International Scientific Film Association. The purpose of this convention was to disseminate information about developments in research, popular science, and educational cinematography since the previous year. The 1965 meeting is being held in Bucharest, Romania, this month.

Before reviewing some of the latest works, however, it is appropriate to devote this first film survey to several older, but well-known films that have been proved scientifically and cinematically sound in recent years:

*Adélie Penguins of the Antarctic* was produced in 1957 for the New York Zoological Society by Evan J. Anton in both color and black and white. It is the first complete record, in motion pictures, of a penguin life cycle, and was photographed by Dr. William J. L. Sladen of Johns Hopkins University as part of his doctoral thesis, presented to Oxford University in 1955. Dr. Sladen first went to the Antarctic in 1948-49 as a medical doctor and biologist to a British expedition, The Falkland Islands Dependencies Survey. His chief objective as a biologist was to make an intensive study of the Adélie Penguin, and he spent that year observing the birds and deciding what to film to illustrate their life cycle. After returning to the Antarctic in 1950-51, he had enough material to make a color sound film of the fascinating life history of the Adélie. Of special significance are scenes showing parent-chick recognition (NATURAL HISTORY, October, 1962).

The six-week fast of the male Adélie is surpassed only by that of the male Emperor Penguin. Gaunt Adélie males are shown guarding their eggs until their mates return from the sea. There are some splendid shots of the nest-relief display that marks the changing of the guard. Other scenes include slow-motion shots that demonstrate the adults' mechanics of propulsion through the water, as well as sequences on how they move on land. For example, they often fall on their bellies and use their flippers to paddle through the snow. On the sound track, rarely heard songs of courtship accompany carefully selected and meaningful displays. Other scenes show the full-grown chicks venturing toward the sea for the first time and plunging into the cold waters.

The awkward motions of these birds will undoubtedly charm youngsters, and scientists and students of ornithology will surely delight in seeing the first complete record of a penguin life cycle in motion pictures.

The purchase price of this twenty-minute film in color is approximately $225; in black and white it is available for about $115. The color print can be rented for approximately $10.

*Echinoderms—Sea Stars and Their Relatives* was produced with the help of Ralph Buchsbaum, Professor of Zoology at the University of Pittsburgh, for *Encyclopedia Britannica* in 1963. This film describes characteristics of the echinoderm body plan and can be used to supplement zoological studies at practically any educational level. Sea stars, sea urchins, brittle stars, sand dollars, and other animals have been photographed and projected with no loss of their natural, brilliant colors, and a good script and occasional diagrams illustrate how these animals are adapted for locomotion, digestion, respiration, and reproduction.

Several experiments are recorded to show how echinoderms can be induced to shed their gametes—both eggs and sperm. In one, an electric current is passed through a female sea urchin, causing it to release eggs. The same method causes streams of sperm to be released by a male. A mixture of sperm and eggs is placed under the microscope, and with the use of photomicrography and time-lapse photography the embryonic development is recorded by the camera. Still another experiment shows an egg that has been subjected to concentrated sea water. It divides without having been fertilized.

This seventeen-minute film can be purchased for approximately $180 in color and $90.00 in black and white, and can be rented for $6.50 in color and $4.50 in black and white. It should be of interest to both high school and college zoology teachers.

*The Leaf Thieves* was written, directed, and produced by Sophy Burnham (former Assistant Curator, Smithsonian Museum Service) in 1964. It records a botanical expedition to the rain forest of British Guiana, where specimens were collected for a new Hall of Botany at the Smithsonian Institution. The thirty-minute film shows how a museum prepares a new exhibit—from the scientist who writes the script for the hall, to the editor who rewrites it for presentation, to the designer who plans exhibition units, to the technicians and administrators who create the exhibit. Many viewers will find the scenes photographed in the museum modelshop the most interesting, for it is here that specimens collected on an expedition are duplicated in finest detail for display. Free copies of *The Leaf Thieves,* in color, may be borrowed by writing to the Smithsonian Museum Service, Smithsonian Institution, Washington, D.C. 20025. The purchase price is $145.

*Plant Traps—Insect Catchers of the Bog Jungle* was produced in 1954 by Dr. William M. Harlow, Professor of Wood Technology at the New York State College of Forestry, Syracuse. This eleven-minute film shows the characteristics and unusual behavior of carnivorous plants. Close-up and time-lapse photography reveal how several of these bog jungle plants, such as the pitcher plant, sundew, and Venus' flytrap, have adapted to their particular environments. Here, presented in a few seconds, is the two-day growth of a sundew, in which the movement of leaves and tentacles has been speeded up about seven thousand times. Other sequences show how the plants react to substances like boiled egg white and raw meat. This film, which should be of interest to photographers as well as to botanists, can be purchased for approximately $120 in color and $60.00 in black and white. It can be rented for approximately $5.00 in color and $3.50 in black and white.

*Eruption of Kilauea, 1959-1960,* is one of several fine movies on volcanoes that have been made available for distribu-ion. It is a thirty-minute, multiaward-winning film in color, which depicts the spectacular upheavals of Kilauea, in Hawaii, over a period of three months. Dr. Edwin Roedder, Geologist in the Geochemistry and Mineralogy Branch of the U.S. Geological Survey, was argely responsible for this produc-ion. The eruption began as a summit outbreak in November, 1959, with ountaining lava confined to Kilauea Iki,

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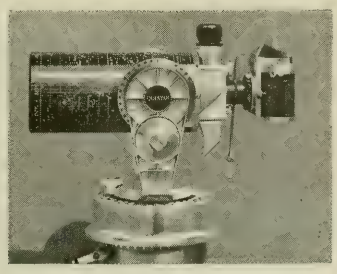

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a small pit crater. This phase continued until the mile-long crater became a 300-foot-deep lava lake covering the erupting vent. The fountaining, followed by lava back-draining into the vent, went through a total of seventeen complete cycles, the last of which ended in December, 1959. Then, after a month of comparative calm, shallow earthquakes and faulting marked the start of a new phase—a flank eruption at the town of Kapoho, 30 miles east of Kilauea. Fountaining lava here completely covered the evacuated town and 2,500 acres of land. This second phase ended in February, 1960.

The bulk of the scenes in this dramatic film are of the eruptions. Shots include lava fountains that reached 1,900 feet (the highest ever recorded in Hawaii), close-ups of liquid lava masses falling into the lava lake, and scenes of other volcanological phenomena, accompanied by actual recordings of fountain noise. A short, animated section shows how volcanoes grow.

Film copies may be purchased from the Motion Picture Service, Department of Agriculture, Washington, D.C. 20025, for $117. A limited number of loan prints are also available from the Map Information Office, Geological Survey, Washington, D.C. 20025, for free circulation to educational institutions and other specialized earth science groups.

*Legend of the Raven*, produced in 1955 by Crawley Films Ltd. for the Imperial Oil Film Services, is distributed by the Humble Oil and Refining Company. Using Eskimo carvings as actors and a weirdly pitched Yugoslavian flute for background music, this thirteen-minute film tells an authentic legend of the Arctic. The story combines both drama and morality, showing how a raven is defeated by its own greediness and is banished from the society of man and animals. The stone and ivory carvings, which belong to the Canadian Handicrafts Guild and to private collectors, are set against a vivid Arctic background and are fine examples of Eskimo sculpture. The raven was carved by Putaguk of Cape Dorset, Baffin Island; numerous carvings were done by the people of this and other islands and the east coast of Hudson Bay. To add further authenticity, songs recorded by Canada's National Museum on Baffin Island are included, and passages are spoken by an Eskimo in his own tongue. An old Eskimo legend comes to life here, preserving an example of Canada's ancient culture. This film may be obtained by writing to Modern Talking Picture Service, 10 Rockefeller Plaza, New York, N. Y. 10020.

*The Hunters* is a seventy-three minute production by the Film Study Center at the Harvard Peabody Museum. Between 1948 and 1958, Lawrence K. Marshall, an industrialist, led several jointly sponsored Harvard University-Smithsonian Institution expeditions through the Kalahari Desert. He took his family with him, and his son, John Marshall, filmed a Bushman tribe's unique struggle for survival during the rainless winter months. Focusing on the tribe's almost ceaseless hunt for food, the film opens with a scene showing women digging for wild roots, and in later scenes boys prepare themselves for manhood by learning to chase and shoot small animals. The major part of the film shows four tribesmen leading an urgent, frustrating, thirteen-day hunt for food in the bleak Kalahari Desert. Mr. Marshall's camera recorded this long, exciting chase from the beginning of the hunt to the final fall of a giraffe.

**Linda S. Gordon**, Docent in Zoology with the Smithsonian Institution's Museum Service, regularly views a diverse selection of scientific films.

Later, at the Harvard Film Study Center, John Marshall edited the film, with the help of Robert G. Gardner, and also wrote the script, which is pleasingly sensitive and dramatically narrated. A color print may be purchased from Contemporary Films, 267 West 25th Street, New York, N. Y. 10001, for $400 or rented for $40. In black and white it sells for $275 and rents for $25.

Unless otherwise indicated, the films reviewed in this column can be bought or rented by writing to the following distributing companies:

Encyclopedia Britannica Films
1150 Wilmette Avenue
Wilmette, Illinois 60091

Moody Institute of Science
11428 Santa Monica Blvd.
Los Angeles, California 90025

Yeshiva University Film Library
526 West 187th Street
New York, New York 10033

Educational Film Sales
University of California
Berkeley, California 94704

This list details the photographer, artist, or other source of illustrations, by page.

COVER—Lee Boltin
12-17—Nancy Flowers, Nancy Palmer Photo Agency
18—Lee Boltin
19—Courtesy of University Museum, University of Pennsylvania
20—AMNH
21—top, André Emmerich; bottom, Lee Boltin
22—André Emmerich
23—Charles Uht, Courtesy of The Museum of Primitive Art
24—left, André Emmerich; right, Lee Boltin
25—Gübelin
26-29—Paul A. Johnsgard except 29—top, AMNH after Paul A. Johnsgard
30—bottom, Mount Wilson and Palomar Observatories
30-31—top, Yerkes Observatory
32—top, Mount Wilson and Palomar Observatories; bottom, AMNH
33—AMNH
34-37—Sally Anne Thompson
38-39—top, Robert C. Frampton; bottom, Hubert A. Lowman
40—top, Robert C. Frampton; bottom left, AMNH after Sherwin Carlquist
40-41—bottom, Brett Weston
43—Hubert A. Lowman
44-49—T.C. Schneirla except 47 and diagrams,
48-49—AMNH after T. C. Schneirla
50—AMNH
51—T. C. Schneirla
52-57—Lee Boltin except diagrams, AMNH after Paul E. Desautels

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# Suggested Additional Reading

## THE FLOATING COMMUNITY OF AMAZONAS

THE NATURALIST ON THE RIVER AMAZON (Revised Edition). H. W. Bates. J. M. Dent, London, 1930.

AMAZON TOWN. C. Wagley. The Macmillan Co., N.Y., 1953.

JOURNEY TO MANAOS. E. P. Hanson. Reynal & Hitchcock, N.Y., 1938.

## MASTER GOLDSMITHS OF SITIO CONTE

COCLE, AN ARCHAEOLOGICAL STUDY OF CENTRAL PANAMA, Part I, Metalwork, and Part II, Ceramics. S. K. Lothrop. Peabody Museum Memoirs, Vols. VII and VIII, Cambridge, 1937 and 1942.

## THE ELUSIVE MUSK DUCKS

HANDBOOK OF WATERFOWL BEHAVIOR. P. A. Johnsgard. Cornell University Press, Ithaca, 1965.

BEHAVIOR OF THE AUSTRALIAN MUSK AND BLUE-BILLED DUCKS. P. A. Johnsgard. *The Auk*, Vol. 82, No. 3, October, 1965.

## RARE CYPRESS CLINGS TO COAST HABITAT

THE SILVA OF CALIFORNIA. W. L. Jepson. University of California Press, Berkeley, 1910.

A NATURAL HISTORY OF WESTERN TREES. D. C. Peattie. Houghton Mifflin, Boston, 1953.

THE NEW WORLD CYPRESSES. C. B. Wolf and W. E. Wagener. *Aliso, Journal of the Rancho Santa Ana Botanic Garden*, Vol. 1, 1948.

## DORYLINES: RAIDING AND IN BIVOUAC

THE ARMY ANTS. T. C. Schneirla in THE SMITHSONIAN TREASURY OF SCIENCE, pages 664-696. Simon & Schuster, N. Y., 1960.

A THEORY OF ARMY-ANT BEHAVIOR BASED UPON THE ANALYSIS OF ACTIVITIES IN A REPRESENTATIVE SPECIES. T. C. Schneirla. *Journal of Comparative Psychology*, Vol. 25, No. 1, pages 51-90, 1938.

FURTHER STUDIES ON THE ARMY-ANT BEHAVIOR PATTERN—MASS ORGANIZATION IN THE SWARM RAIDERS. T. C. Schneirla. *Journal of Comparative Psychology*, Vol. 29, No. 3, pages 401-460, 1940.

## INTERACTION BETWEEN LIGHT AND MINERALS

GEMS. R. Webster. Butterworths, Washington, 1962.

GEMSTONES. G. F. H. Smith. Pitman Pub. Co., N.Y., 1949.

DANA'S MANUAL OF MINERALOGY. C. S. Hurlbut, Jr. John Wiley & Sons, N.Y., 1959.

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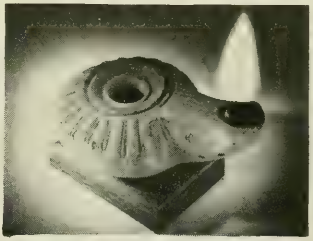

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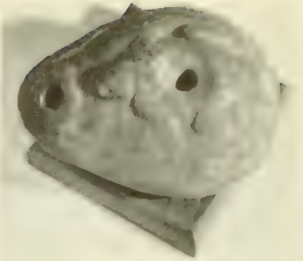

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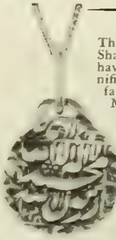

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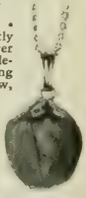

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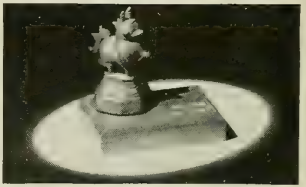

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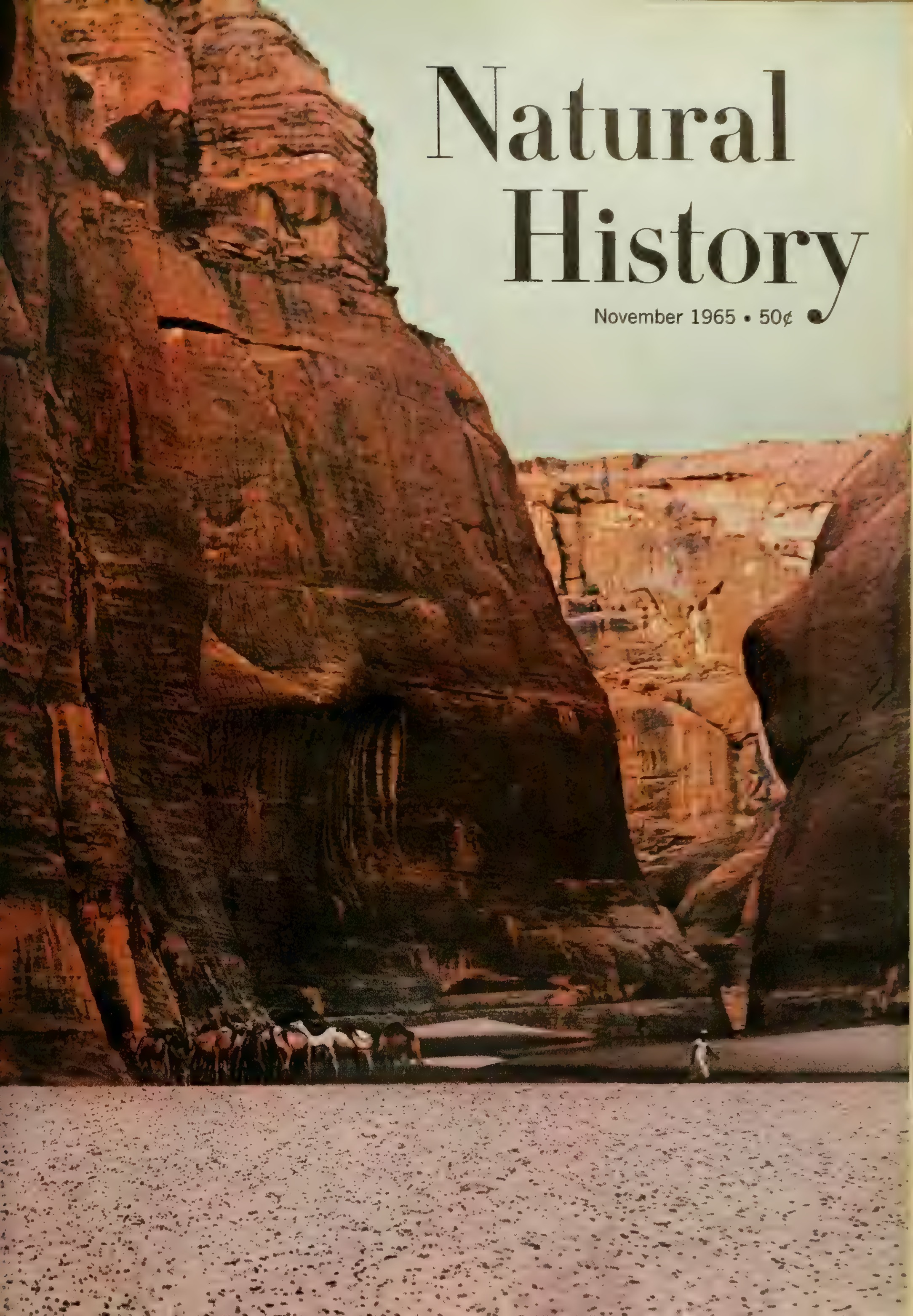

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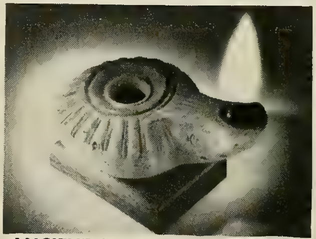

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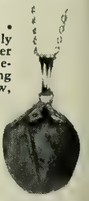

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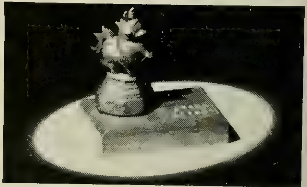

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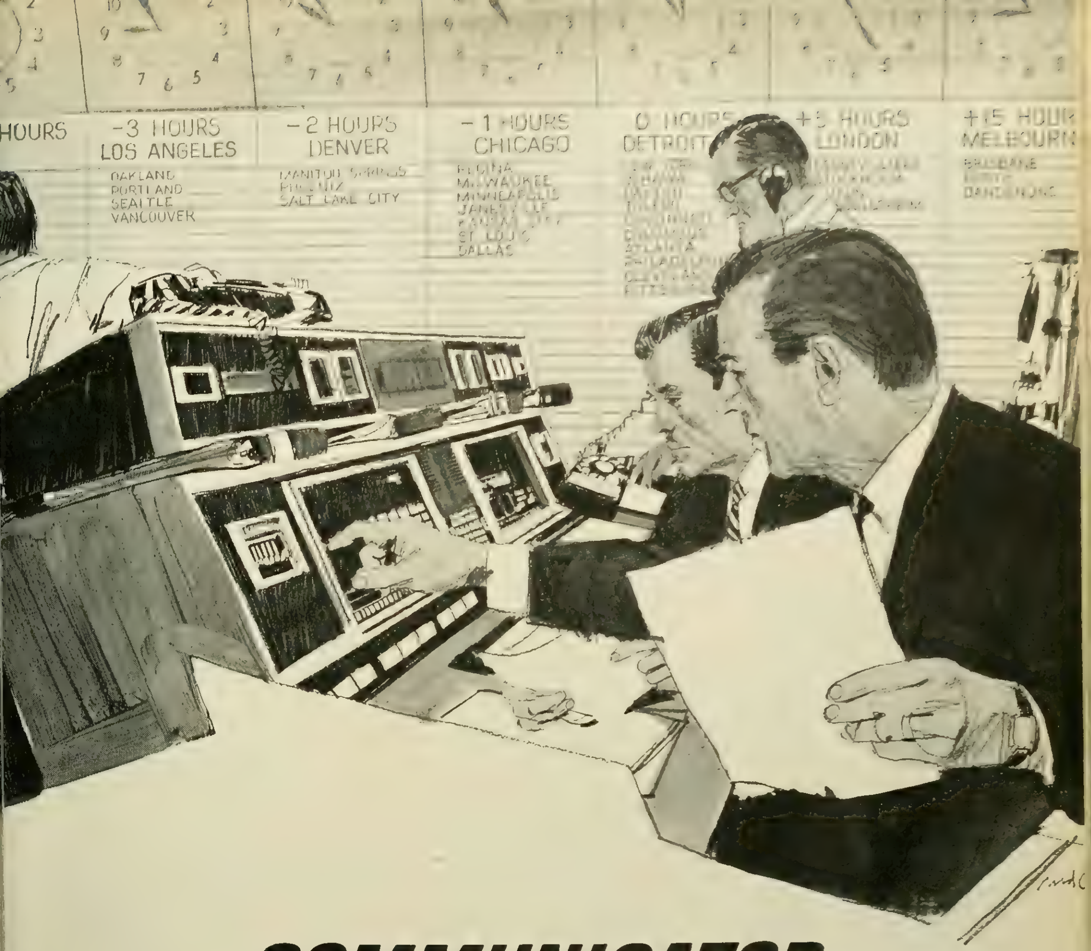

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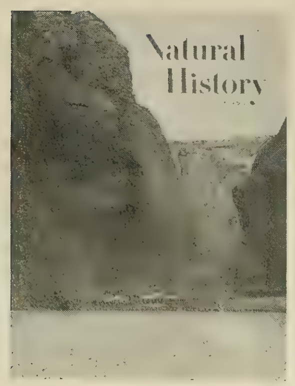

# Natural History

Incorporating Nature Magazine

*THE JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY*

Vol. LXXIV NOVEMBER 1965 No. 9

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COVER: The towering mass of the sandstone cliffs that surround the wadi and the guelta of Archei were photographed by W. Gurnee Dyer during a trip that he and Mrs. Dyer made through the Tchad's remote Ennedi region, which lies in the south Sahara. In an article beginning on page 36, Mr. Dyer tells of their journey from Abéché to Fada. The word "guelta" refers specifically to a pool in a rocky stream bed that holds water after a rainy period, but remains dry for a large part of the year. In the guelta of Archei the water is reduced during the day by man and beast; at night it is apparently filled by seepage through fissures.

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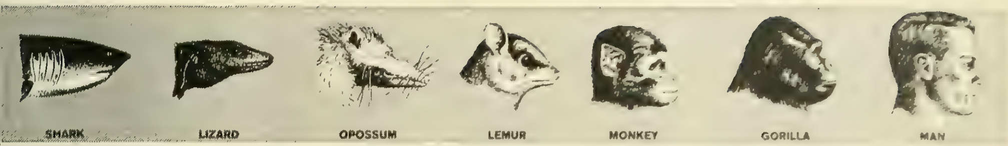

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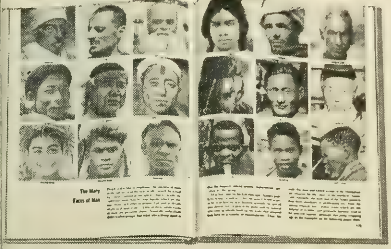

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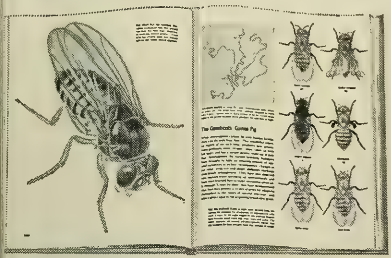

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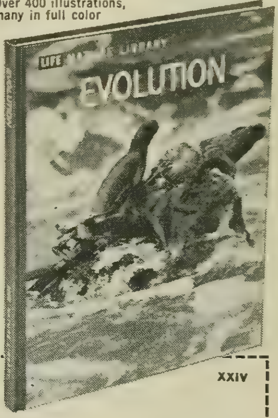

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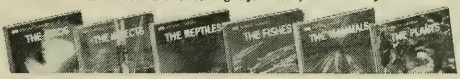

# Natural History's 1965 Survey

"The books I have read for this year's roundup are certainly more accurate scientifically than those of the last five years," said one of our regular reviewers recently. "I wonder if that means more specialists are being asked to check texts before they're published?" Only the authors and publishers can answer that question, of course, and not all our other reviewers agree with the first statement. However, it is the first time in the history of this survey that so cheering a remark has been made.

For the sixth year NATURAL HISTORY is presenting "reviews in depth" of books in the biological and earth sciences and in astronomy written for, or of interest to, junior and senior high school readers. The reviewers are all associated with the scientific staff of The American Museum of Natural History.

By far the greatest number of books this year fall into two categories: anthropology (including archeology) and general zoology. A paucity is apparent in botany and ecology, geology and paleontology, and astronomy—an observation we might call to the attention of those individuals and/or companies who are most directly concerned with the production of books for young people.

As in previous years, reprints of this year's survey will be made available without cost to teachers and librarians who write us on their official letterhead and include a stamped, self-addressed envelope. Any other readers who wish reprints may obtain them at the cost price of 20 cents apiece.

Requests should be sent to: Reviews, NATURAL HISTORY, Central Park West at 79th Street, New York, N.Y. 10024.

## Anthropology

As the prospect for the future broadens and deepens for the younger generation—who live with the exploration of space and move in a world that has become one network of communicating peoples—it is significant that so much writing intended for today's youth attempts to open a broader view to the past. The majority of the books that take young Americans to unfamiliar places are concerned, not with men living in the contemporary world, but with earlier civilizations. Some are written in an already familiar pattern around the formula of the discoverer—adventurer, explorer, or scientist—who succeeds beyond expectation in opening the way to knowledge about an older culture, finds some store of treasure, or stumbles on an unsuspected phase of man's history. Certain paths to the past are becoming well-traveled highways. Schliemann, Evans, Cook, and others have become almost stock figures. Troy, Crete, dynastic Egypt, and the high civilizations of the New World have become familiar attractions. There is also a highly standardized vocabulary. Such words as "strange," "mysterious," "riddle," and "treasure," and their synonyms, provide a framework for thinking that sets the past apart from the present.

Occasionally a book really succeeds in creating a sense of the present in the past. *Mesopotamia*, by Walter A. Fairservis, Jr. (Macmillan), is a book in which a scholar's familiarity with a landscape and his delight with his material bring to vivid life the earliest city builders we know about. The author is an archeologist who moves confidently between past and present, and in his hands the objects, the architecture, and the early scripts take on color and movement and sensuous pleasure.

Books describing how archeologists work allow the authors to range the world in time and space. In *Digs and Diggers* (World), Leonard Cottrell takes as his theme the development of modern archeology over the past 150 years. This permits him to write about the Old World and the New—Egypt, Mesopotamia, Greece, Crete, Europe, the Indus Valley, the high civilizations of the Americas—and to discuss some of the men and techniques involved in the creation of a many-branched science. The book is well illustrated with black-and-white photographs. Henry Garnett's *Treasures of Yesterday* (Natural History Press) also attempts to familiarize the reader with the "where's," "why's," and "how's" of archeology, to present the setting of man's long history, and to demonstrate correctly how the archeologist works in piecing that history together. The book is profusely and colorfully illustrated, but it loses rather than gains by the wide assortment of types of illustration. *Archeology* (The Metropolitan Museum of Art), a shorter and less ambitious book, by Edith Whitney Watts, succeeds in giving a clearer picture of what the archeologist does to build up his records, for here text and black-and-white illustrations work together to give the reader a step-by-step account of techniques. *The Riddle of the Past* (Norton) also describes how archeologists work, but Gordon C. Baldwin writes mainly about North American sites (with brief excursions to Egypt and Ur). This is a pleasantly homely book written in a style intended to interest, particularly, the teen-age boy who wants to find out how archeologists "detect."

Other books deal with one time and place. Two are about Egypt: *The Two Reigns of Tutankhamen* (Putnam), by William Wise, and *The Secrets of Tutankhamen's Tomb* (New York Graphic Society), by Leonard Cottrell. The former attempts to build a history of Egypt and to describe a way of life around the figure of the young king; it is full of generalizations and many fanciful details. Yet, it may interest younger readers. Cottrell, in contrast, focuses directly on the discovery of the tomb by Howard Carter and discusses the inferences that can be drawn from its marvelous contents. These are two quite different approaches to the stuff of history. In *Crete, Island of Mystery* (Prentice Hall), Cottrell tells once more the familiar story of Schliemann's discoveries in Troy, Mycenae, and Tiryns, and of Sir Arthur Evans' lifetime work in Crete. Although this is standard knowledge, Cottrell does a workman-like job. The book is only somewhat marred by its sketchy illustrations, which do not do justice to Crete's rich materials.

Africa, unfortunately, comes off poorly in this year's crop of books. Ronald Syme's *Nigerian Pioneer* (Morrow) tells in stilted style the story of Mary Slessor, a Scottish missionary who spent almost forty years at her work. Africa is described in a manner that must have been familiar to Sunday schools at the turn of the century. *Ifrikiya* (Putnam), by Louis Wolfe, presents ten "true" stories about nineteenth-century figures —David Livingstone, Howard Carter, Ferdinand de Lesseps, Paul Kruger, Cecil Rhodes, and others less well known —in flat, fictionalized form. *A Glorious Age In Africa* (Zenith Books), by Daniel Chu and Elliott Skinner, an anthropologist, attempts to provide background for part of modern Africa. The book gives descriptive histories, spanning about ten centuries, of three old kingdoms of the Sudan—Ghana, Mali, and Songhay—and makes an effort to reconstruct past ways of life. But the underlying theme, which is that Africans have had as long a history as the Euro-Americans, is not carried through into a discussion of how African history has become known, so it has an old-fashioned ring.

Two books take us to the New World. James Norman's *The Forgotten Empire* (Putnam) vaguely describes Mayan civilization and, more particularly, the rediscovery of the Mayans, beginning with John Lloyd Stephens' and Frederick Catherwood's adventures in their search for Copán. Norman has a special style of utilizing curious metaphors in relation

# of Science Books for Young People

to his context. Thus, he writes that Presscott "worked like a Trojan" and that Diego de Landa "served as the Boswell of Mayan life." In contrast, *Cortez and the Aztec Conquest* (American Heritage), by Irwin R. Blacker, is absorbing and delightful, both because of the care with which the events have been put together and because of the richness of the illustrations, in black and white and pleasant colors, which suggest how differently the men and the events have been visualized through time.

Three books take us to the Pacific. *Seafarers of the Pacific* (World), by Douglas Newton, Curator of The Museum of Primitive Art in New York, is a somewhat generalized, simple book about Polynesia and Polynesians. It has a good map, impressionistic black-and-white illustrations, and a chronological chart linking events in Polynesia to the larger world. The book emphasizes what was common to Polynesian cultures, rather than what differentiated them. In *Fiji: Islands of the Dawn* (Washburn), Leonard Wibberley moves freely from history to descriptions of present-day life, and to his own observations as a casual, but alert, visitor. *Forever the Land of Men* (Dodd, Mead) deals with the Marquesan Islanders with great charm. Willowdean C. Handy, the author, accompanied the 1920-21 Bayard Dominick expedition as the wife of an anthropologist, and she writes about her personal recollections with warmth and depth of feeling. Here anthropology is built in as the firm basis of her relations with the Marquesans. It could have been a sad book about a broken culture; instead, it glows with life and sympathy that bridge the years and the changing ways of looking at the world.

One book turns to Europe. In *The Northmen* (World), Thomas Caldecot Chubb writes with verve and directness about the civilization and far-flung movements of the people we usually call Vikings. Most younger readers will not be familiar with the Viking excursions across Europe to the Middle East or with their vast journeyings to the New World long before the age of discovery. A chronological chart helps the reader to map the activities of the Northmen.

Two excellent books will interest readers who are discovering the world through art forms. Robert Myron, author of *Shadow of the Hawk* (Putnam), combines professional training in art history and archeology and writes from this double viewpoint about the ancient Hopewell and Adena Indians, the Mound Builders of the Ohio River Valley. This book, intended for younger readers, is factually written and continually shows the relationship between archeological materials and the inferences to be drawn from them. At the same time, Myron analyzes the Mound Builders' production with a keen appreciation of a people's creative imagination. *The Story of Moslem Art* (Dutton), illustrated with photographs and drawings by the author, Christine Price, is a most successful book. It weaves together a thousand years of history and the development of an artistic tradition that in time influenced, and was influenced by, the art styles of peoples all the way from western Europe to the Middle East and China. A book of this kind, which delineates the ebb and flow of imagination embodied in art and architecture, is itself a work of art.

In *Anthropologists and What They Do* (Watts), Margaret Mead gives the reader a glimpse of anthropologists at work in The American Museum of Natural History and at Columbia University through interviews with members of anthropology departments of these two institutions. She takes the reader into her office and into the field in Samoa and New Guinea. This is a book both for the reader with an awakening curiosity about who anthropologists are and what they do at home and abroad, and for the student whose feet are tentatively set on this path as a way of life. An appendix gives careful, practical suggestions for trying out some first steps.

Most of these books contain bibliographies, and several give the reader some background on the sources of illustrations. Some also provide chronologies. But few of them (Margaret Mead's book is an exception) attempt to guide the reader who goes to the library to look for beginning points or areas of specialization. Usually the reader must guess and try. A book of the kind described here, about history and ways of living, should not be an end in itself, but a beginning.

RHODA METRAUX

## Astronomy

In the last few years, a large number of the astronomy books for young people that I have been offered for review have had several things in common. They had large type, many illustrations, few pages, and were a quick run-through of the same old subjects. Some were good in the way they presented the material, others were unbelievably poor. Few were mediocre. This year the situation is somewhat different. Hopefully, a trend is developing, but it may turn out to be merely a statistical fluctuation. Three of the eight books reviewed this year are long and meaty. Two of these are best-suited to interested high school students, their parents and teachers, and to beginning amateurs. The third is good for junior high school students, who have a flair for science but who still like it simple.

The first is *Stars and Planets*, by James Muirden (Crowell). The design of this book will win no prizes, and the writing (initially for a British audience) occasionally seems stiff. But the subjects themselves are sufficient entertainment for a budding astronomer. The author often mentions things to be seen with a small telescope, thus aiding a reader's drive to have an instrument for himself. The book ends its survey of the planets, stars, nebulae, and galaxies with some practical advice on establishing a personal observatory and joining an amateur group.

The second serious work is *Pictorial Guide to the Planets*, by Joseph H. Jackson (Crowell). There are indeed many pictures in this book, but there are also many pages unrelieved by an illustration. Many of the reproductions are especially welcome because they have not been in common use in the popular field, but the title seems to promise much more than it offers. The text is readable and full of interesting information—and the author keeps to the solar system. Again, the title claims the work to be a guide, and in this era we might expect to find a cute attempt to provide a real guidebook for a space traveler, but fortunately this is not so. Perhaps a quarter of the book is devoted to rocketry, satellites, probes, and man in space, but the subjects are treated in a factual manner in keeping with the presentation of astronomy. The whole is well done and easy to take, even without a compelling interest.

The third title is *Sun, Moon and Stars*, by W. T. Skilling and R. S. Richardson (McGraw-Hill). This is a "revised and enlarged" version of their earlier work of the same name first published in 1946. It looks somewhat like a textbook, but is not written like one. Occasionally, the authors break into fantasy to dramatize a difficult point. They may place the reader on a remote planet to help him visualize the peculiar conditions, or they may present a dialogue after the manner of Dante so that a questioning traveler (the reader) may learn from a knowledgeable guide. I suspect this technique may pall on a senior high school student, but it may strike home to one in junior high. Another helpful inclusion for the beginner

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is the indication of the pronunciation of peculiarly astronomical words, many of which are not at all obvious. (A youngster always likes to know things that are "official.")

Even though the authors are long-time astronomers engaged in research, teaching, and writing, it is possible for slips to occur. One unfortunate example involves their treatment of sunspots. An illustration pictures Herschel's theory of these phenomena. It is not until eight pages later that the text correctly states that his theory is completely wrong. The obvious question arises: Why present an elaborate, illustrative demonstration of a wrong concept in the first place? Let us hope for an early new printing so this may be corrected. It would then be possible to correct the footnote that states that the star Alpha Centauri may be seen from Florida and the "Texas Panhandle." This surely means the Brownsville, rather than the Amarillo, region of Texas. And in my copy, the illustration on page 97 is a poorly printed photograph of a solar tower telescope at Mount Wilson distorted by the sun glaring frightfully around the side of the dome. Finally, one clever picture shows a mirror "being adjusted by an astronomer." Credit is given the photographer, but his considerable number of well-deserved fans might like to know that the astronomer is co-author Richardson himself.

Random House has published another in its "All About . . ." series, this time *All About the Universe*, written by David Dietz. There is nothing wrong with this book, but it is hard to tell all about the universe in 144 pages, perhaps 40 per cent of which are pictures. Some youngsters who read it may be naïve enough to believe there is nothing left to know about the universe. Perhaps we don't want that kind of person in science, anyway. But give credit to Mr. Dietz. He did as well as anyone could in this non-convergent series.

*Our World in Space* (Macrae Smith) was written by Henry C. King, Director of The London Planetarium. This "Easy Guide to the Universe," according to the subtitle, is a fine introduction for early junior high school students, but I feel it is not up to Dr. King's exciting style. It may not arouse the ordinarily overstimulated American youngster to continue reading in astronomy.

Willy Ley usually makes a dramatic presentation of any subject. Astronomy, and especially space travel, may easily be treated dramatically, and he has done it again in *Beyond the Solar System* (Viking). Chesley Bonestell, listed as co-author, has provided about sixteen of his beautiful and thoughtful illustrations. Mr. Ley discusses some of the properties of the solar system, then considers the physical problems of literally getting to Alpha Centauri, the nearest star to the sun. He readily acknowledges that the solutions to technological problems are currently imponderable, but he states what difficulties must be overcome on such a trip, and what planetary configurations might prevail in such a double star system as Alpha Centauri.

The author then proceeds to the astronomy of the stars and the Galaxy. His historical accounts are interesting, but his discussion of stellar evolution is nearly fifteen years out of date, and poor editing is disturbing in some other places. For instance, we are told that about a century ago Father Secchi found four spectral classes sufficient to account for most of the stars. Only three of the classes are enumerated. In another place, we read that the eclipsing star system Algol consists of a G0 star (yellow) and a B8 star (blue-white), four times brighter. But three pages farther on we read that "Algol is a binary consisting of two nearly identical Red Giants. . . ." And two pages after *that*, there seems to be some very suspect scientific reasoning anent Rigel: "For brighter Main Sequence stars such as Sirius, the present life expectancy [is about] 240 million years, but the life expectancy of Rigel is only 8 million years, and that of the very luminous supergiant UW Canis Majoris . . . is only 300,000 years. There can be no bickering with the method of calculation, especially since it produces reasonable figures for the 'lesser lights,' but a life expectancy of only 8 million years for Rigel simply does not look right. On the basis of this we must calculate that Rigel was formed only about 200 million years ago." Rigel has its problems, but they need not be complicated by such arbitrary handling.

Nevertheless, this book is not bad if read by someone who already knows enough astronomy to detect its flaws for himself. It contains many well-presented, interesting ideas.

Approaching the dark end of the literature spectrum, we find *Life in Other Solar Systems*, by Frederick I. Ordway, III (Dutton). The author, on the first page of Chapter 1, mentions that a previous effort (with another writer) is a companion work to this one. That "companion" was reviewed in these columns two years ago, and I have the pleasure to report that Mr. Ordway's new volume is a considerable improvement.

The author reviews the solar system and the universe in the first two chapters and discusses the possible origin of planetary systems. Chapter 3 is a discussion of life, its environmental needs, and the conditions for its beginning in the first place. With this in mind, he describes possible planetary configurations that can and cannot support life. The fourth chapter deals with detect-

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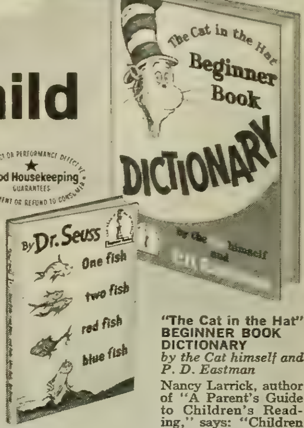

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ing and communicating with other "extrasolar civilizations." After wondering if we have ever been visited, he discusses, in Chapter 5, some of the problems of traveling through interstellar space. A large fraction of the next chapter is devoted to several curious fantasies about other life forms, life chemistries, and even inorganic life in the form of self-perpetuating supermachines.

And in the final chapter, he climbs nearly to infinity (because it is there?). "If a society at one edge of the Milky Way should find it necessary to seek information from a society at the opposite edge, it would have to wait 160,000 years for a reply (80,000 years for the inquiring signal to reach its destination plus 80,000 years for the answer to be received). It is hard to visualize what sort of information would be useful to a community 160,000 years after a need for it had been expressed, but virtually anything is possible on a cosmic scale. Now that we are thinking in such awesome terms, we may as well stretch our imagination even further and ask ourselves if there is likely to be a communication channel between galaxies. Surely, advanced societies in one galaxy will wonder if intelligent life has evolved in neighboring galaxies and can be expected to make supreme efforts—if only to satisfy their scientific curiosity—to find out." He acknowledges this *may* not be feasible in practice, considering the million or more years of transit time involved. Then why bring it up as a fact ("Surely . . .")?

The author acknowledges indebtedness to the investigators who "have helped transfer [this] subject from the pages of science fiction to the realm of legitimate scientific inquiry." Many of Mr. Ordway's remarks may be traced to a few publications, anthologies, and reports of private meetings. These usually contained "brainstorm ideas" admittedly exposed to foster argument and discussion. It appears that our present author took many of them for real, considered scientific opinions and leaped off from there. If a reader takes this book in the spirit of brainstorming, he can find a lot of fun and food for thought.

He will also find the drawings entertaining in two ways. They are pretty to look at, for the artist is good, and he will puzzle over the information content in them, for it is infinitesimal. One set of diagrams (pages 57 and 58), carefully numbered to correlate with the text, provides a few moments of hilarity. But the amusement leaves a note of sadness when you realize that so many intelligent people worked so hard to be so ridiculous.

*The Space Around Us*, by A. Edward Tyler (Harper & Row), must be read by someone who knows the subjects involved. Mr. Tyler has an interesting idea about space—the ocean around us filled with fast-moving particles, the plasma that is the solar wind, the fields of radiation streaming from the sun and stars, and electrostatic and magnetic forces. A knowledgeable person will gloss over glaring errors such as a hydrogen molecule breaking up into its component ions $H^+$ and $H^-$ (it merely becomes two neutral hydrogen atoms), and the sun having a central density 2.5 times that of water (it is more like 150 times), and a wavelength of 0.7 Ångströms for red light (it is 7,000 Ångströms, or 0.7 microns). A knowledgeable person may not like to see gravity balanced by centrifugal force to keep a body in orbit, and he will surely wince at the author's inclusion of his theory that comets are not so much material as they are disembodied magnetic vortexes interacting with the interplanetary material and fields.

After this curious introduction, there follows a discussion of space age technology that I find impossible to review with competence. In my opinion, the narrative method of describing people (and types) in Chapter 8 is really good. Perhaps Mr. Tyler would shine as a writer of enjoyable, readable science fiction.

K. L. Franklin

## Botany and Ecology

This year's seven books can be divided conveniently into three broad categories—general botanical treatments, tree books, and geographical ecology, or travel guides. *The Lore of Living Plants* (McGraw-Hill) was written by Johannes van Overbeek, Chief Plant Physiologist for the Shell Development Laboratory, with a project section by Harry K. Wong. It is an exceptionally fine introduction to the current knowledge of plant physiology. Although the writing is clear, with a minimum of jargon, it is a difficult book and will make its readers stand on mental tiptoe to follow the energy exchanges and biochemical pathways described in the discussions of photosynthesis, respiration, and other processes.

*Wonder World of Microbes* (new second edition, McGraw-Hill), by Madeleine P. Grant, is a highly popularized account of bacteria, protozoa, viruses, and other microorganisms. It includes generalized discussions of their biology, economic and ecologic importance, and methods used to combat disease-producing forms. The book is overpopularized for my personal taste, but it might appeal to others. However, a number of anthropomorphisms—air-hating bacteria, sugar-loving yeasts, spores "just waiting for things to be right so that they can sprout"—and some sweeping generalizations have been introduced. *Microbes and Men* (McGraw-Hill), by Harold J. Simon (reviewed in Natural History,

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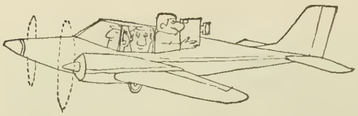

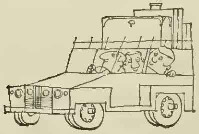

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November, 1964), appeals to me as a more thorough and precisely written coverage of this subject.

*The How and Why Wonder Book of Trees*, by Geoffrey Coe (Wonder Books), is riddled with errors and brims with teleological statements. The best advice I can offer is to avoid it. This opinion can be extended to *A Tree is Born*, by J. M. Guilcher and R. H. Noailles (Sterling). This book consists of an excellent series of black-and-white photographs accompanied by a thoroughly anthropomorphic text that occasionally is interrupted by an accurate statement.

*Portrait of an Island*, by Mildred and John Teal (Atheneum), is a naturalist's guide to Sapelo Island, one of the many "sea islands" along the Georgia coast. It is chiefly an account of the authors' observations during the four years they worked at the Marine Institute of the University of Georgia. It will be most useful to island visitors, and the informal observations on insects, lizards, birds, and other animals of land, shore, and salt marsh provide interesting reading for the armchair adventurer.

The outstanding section of the book is a lucid description of the productivity and feeding relations of salt-marsh organisms. It is drawn from studies by many Marine Institute investigators and presents energy budget figures for the Sapelo marshes, whose general features doubtless apply to much of the grassland that fringes the Atlantic and Gulf coasts from southern New England to Texas.

John Hoke's *The First Book of the Jungle* (Watts) describes forms of tropical vegetation, especially those of the rain forest, as well as the animals and humans that live in it. The locale is British Guiana on the central northern coast of South America. My own acquaintance with jungles is so limited that my evaluation of the book can be based only on its style of presentation of data and the appeal of its prose. Briefly, I found the book interesting and informative. Regrettably, however, the text is marred by the too-common fault of popular writers—anthropomorphism. For example, vines are said to "search for sunlight." How much more fascinating it is to understand that this easily misinterpreted growth toward the brighter light of the treetops is the result of stimulations received from a complex light environment and a long, related series of internal changes in the chemistry and growth pattern of the plant shoot. The delicate mechanisms of plants and animals make the most highly refined automatic controls designed by man seem bulky, clumsy, and undependable.

The Young Readers' Edition of Peter Farb's *Face of North America* (Harper & Row) is a popularized introduction to the geomorphology of our continent. The major vegetation types of the continent also are described, but the biological data are definitely secondary to the dynamic account of landscape development. An exceptional collection of black-and-white photographs will assist the reader in relating the processes described to the land forms they produce.

I disagree with many statements in the text, however, and suspect that several errors were generated when the author paraphrased information from references he consulted. Some of the biological interpretation either is erroneous or decidedly "old hat." The book obviously is a popularization of several standard textbooks on geomorphology and physiography but, surprisingly, none of these is mentioned in the acknowledgments or cited in the list of suggested readings. John A. Shimer's *This Sculptured Earth* (Columbia University Press, 1959) is, in my opinion, a more thorough and reliable book on America's landscape. Shimer's book lacks information on vegetation and animals, but this should not be considered a major drawback. Farb's biology is largely superficial and is not integrated with the geomorphology and physiography that are the mainstays of the volume.

JACK McCORMICK

## Geography, Geology and Paleontology

THE intellectual activity known as science is man's continuing attempt to understand the universe in which he lives. To obtain a factual basis for contemplation, science must first make observations of natural phenomena. This part of science—the empirical part—is basic, for we can hardly speculate usefully about nothing.

Geology and geography, like other branches of natural science, thus depend heavily on detailed and accurate observations of phenomena: What is the exact distribution of land and sea? What kind of rocks make up the continents and the ocean basins? How many different kinds of rocks are there and how do they differ from each other? How old is the oldest known fossil and what kind is it? Where do we find fossil animals and plants? Are they related to living animals? The answers to these questions, and countless others, form the factual, or empirical, side of geology and geography.

All sciences must have a theoretical or conceptual side to complement the empirical; this follows from the basic objective of science, which is to understand the universe. Thus the factual part of geology asks, "What is the world like?" while the theoretical side asks, "Why is it like this?" Why are land and sea distributed the way they are? Why did mountain ranges like the Alps de-

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velop during a particular part of the earth's history? Why did dinosaurs evolve? Why did they become extinct? Why do deserts develop in some places and not in others?

To be considered truly scientific, a volume should introduce the reader to both the empirical and the theoretical sides of science. The proper balance is difficult to strike, and few books for the general reader achieve it. None of the nine books reviewed here is fully satisfactory on this point, most of them providing the reader with a strictly empirical view of the subject.

One, *The Habitable Earth*, goes to the opposite extreme and provides the reader with such a heady brew of theory and speculation that only a professional geologist with a solid background of fact can understand and properly evaluate it. Two others, *This Thirsty World* and *Deserts*, attempt theoretical and factual coverage, but are far too skimpy on the theoretical side. They will be discussed later in more detail.

Three of the books are really stories of adventure and geographic discovery by early explorers, rather than science books, and should be judged on that basis. The best of these is Ann and Myron Sutton's *Journey Into Ice* (Rand McNally). This is the life story of the little-known English explorer John Franklin, who, during the second quarter of the nineteenth century, made substantial contributions to the geographical knowledge of northern Canada. Beginning with Franklin's adventures as a young man on cruises to the South Pacific (including a shipwreck off Australia), the book follows his career to the discovery of the long-sought Northwest Passage, and concludes with the tragic but fascinating story of the loss of his final expedition somewhere in the frozen wastelands near Victoria Strait. The authors have done a fine job of research, and present an interesting account of a virtually forgotten geographer.

Another good book that is essentially a story of adventure and exploration is *The Loneliest Continent*, by Walker Chapman (New York Graphic Society). Here the focus is on the Antarctic region itself, rather than on a man, and the long, still-continuing history of exploration is well covered, beginning with Greek speculations dated 400 B.C. Good, more lavishly illustrated books on this subject are available, but Chapman's volume stands comparison in other ways.

*First Around the World*, by George Sanderlin (Harper & Row), is quite a different sort of exploration and adventure yarn. Here we are given, mostly from original sources, the story of the first round-the-world voyage by Magellan. Much of the book is taken from James A. Robertson's 1906 translation of a journal kept by Antonio Pigafetta, a

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gentleman adventurer who accompanied Magellan on the epoch-making trip.

The author has interwoven portions of this journal with portions of other contemporary documents, and has provided bridge passages and commentary. The result is an unusual and valuable contribution to the literature of discovery and exploration, although, from the point of view of literary style, the book is a bit disjointed. If the reader will overlook this flaw, however, he will have the satisfaction of gaining firsthand insight into an important page of history. Magellan's struggle emerges as a truly heroic one. He did much more than persevere into unknown, dangerous waters; he fought mutiny and an active program of sabotage financed by the King of Portugal. His death before the completion of the voyage and the disregard of provisions in his will give the story a sad, final twist. Among the interesting illustrations are reproductions of two world globes made in 1492 and 1515. These document dramatically the cartographic vacuum into which Magellan sailed.

*Exploring the World of Fossils*, by William H. Matthews III (Childrens Press), is a good introduction to the basic facts of fossils—what they are, how they are formed, and where we find them. The format of the text and illustrations is attractive, and the young reader will learn with pleasure some of the essential anatomical facts of major groups of organisms commonly found as fossils. He will learn how and where to collect them and will be introduced into the complexities of fossil nomenclature. The real inadequacy of the book is that the exciting world of interpretation of fossil floras and faunas in terms of evolutionary processes is barely touched on.

A striking contrast to the Matthews book is *The Habitable Earth*, by Ronald Fraser (Basic Books). Here is a volume that attempts to give the reader a streamlined and up-to-date picture of the earth's major features as viewed by the geologist and geophysicist. The technique employed is to skim past the basic, solid facts of minerals, rocks, landscapes, and surface structures, and to plunge into a highly theoretical analysis of the planet as a whole—the structure of the crust, mantle, and core; the origin of mountains and continents; the dynamics of oceanic and atmospheric fluids.

Within five pages after the start of the text the reader is given a compressed and inaccurate analysis of the speed of seismic waves as related to the nature of the transmitting material. Within eight pages he is studying the magnetohydrodynamics of the earth's core; and so on. The author himself is not competent in these areas, and has relied on discussions with scientists and on secondary research sources. In itself, this is no crime, but he has also unfor-

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tunately indulged in value judgments beyond his competence. The result is a book for which no appropriate audience exists: it is far too complicated for the young reader; unbalanced for the mature, educated layman; and worthless for the scientist.

*This Thirsty World*, by Alfred Lewis (McGraw-Hill), is a good, small, timely book on the problems of water supply. The scientific background is discussed, although too briefly. The bulk of the text describes the uses of water and the problems of flood control, irrigation, water power, and water supply. It will provide background for thought on one of our most pressing national problems.

An excellent small book in a similar conservationist vein is *Taming Asia's Indus River*, by Charles R. Joy (Coward-McCann). A brief, well-done text, good maps, and photographs are used to explain the vital role that water resources connected with the Indus River play in the political, economic, and social life of West Pakistan and adjacent parts of India. The political struggles involved in developing the Indus Valley effectively are covered, and the roles played by Pakistan's Water and Power Development Authority, UNESCO, and 15.2 million United States dollars are clearly brought out. This volume is a valuable contribution and will provide factual background for intelligent evaluation of United States foreign aid programs.

*Deserts*, by Alonzo W. Pond (Norton), is a good, but not outstanding, book on arid lands. It is basically concerned with desert lore, rather than desert science.

Undoubtedly the only unique book reviewed in this section is *Dinosaur Hunt*, by George O. Whitaker and Joan Meyers (Harcourt, Brace & World). The senior author is a collector and preparator of worldwide reputation, and head of the preparation laboratory at The American Museum of Natural History's Department of Vertebrate Paleontology. The book is a detailed account of the discovery, extraction, and preparation of an important find of the first complete known skeletons of *Coelophysis*—a small, early dinosaur. For any reader who has enjoyed, and profited from, viewing the skeletons of dinosaurs or other extinct vertebrate animals in a museum, and wondered how paleontologists find these remains, extract them from the entombing rocks, and prepare them for exhibition, this book will provide real insight into fascinating, behind-the-scenes activities. It is well illustrated and interestingly written.

JOHN IMBRIE

## Zoology

The dreadful paucity of originality, of subject selection, and of distinctive style in presentation becomes more apparent as reviewing years go past. I have a gnawing feeling that I have already read many of the books reviewed below, either in their young adult versions, or in their original adult forms. In addition, the young people's market in science books seems to be flooded regularly with compilations of animal stories, frequently based on photographs or stories that have been published previously in newspapers or magazines, that offer little education on scientific matters. Of course, if they arouse curiosity or if they stimulate further exploration, they will have served some purpose.

Yet, there are several this year that are original—either in the method of discussing an old subject or, more rarely, in the presentation of a new one. Perhaps optimistically, I feel that the freshness of these few provides a note of encouragement to a sometimes-depressed reviewer; they may, just possibly, be harbingers of a trend toward publishing originality.

Starting at the very edge of the sea, we have a well-organized book, *Tide Pools & Beaches*, by Elizabeth Clemons (Knopf). Clean, crisp writing is complemented by the clear, brisk drawings. Each animal or plant is labeled with both its common and scientific name and its geographic range—primarily the Pacific or Atlantic coasts. The book treats some of the commonly found invertebrate fauna, such as starfish, sea urchins, crabs, anemones, corals, barnacles, and the red, green, and brown seaweeds. Missing, however, are snails, clams, and mussels.

Techniques for preserving the specimens are included, and the artistically inclined collector will discover the beauty of pressed seaweeds. There is an index and a good explanation of how to read a tide table. I recommend the book, and suggest that a place be found for it in beachside houses. And has any public beach considered the possibility of a reference library for curious beachcombers that would include books such as this?

Going to greater depths—oceanographically speaking—is *Exploring Under the Sea*, by J. Gordon Cook (Abelard—Schuman). It is a history of man's attempts to explore the bottom of the ocean, and there are many illustrations of old and new devices for such explorations. It traces man's problems — the physiological ones of surviving in the sea and the mechanical ones of designing devices that will withstand the enormous water pressure. Part of the theme of the book is a plea for more research on the oceans, our inner space.

The work is competent, but the subject matter is standard and can be found in many histories of diving that have been published during the past fifteen years. Despite its good points, it is an example of a book that "one has read before."

Another such is *World Beneath the Oceans*, by T. S. Gaskell (Natural His-

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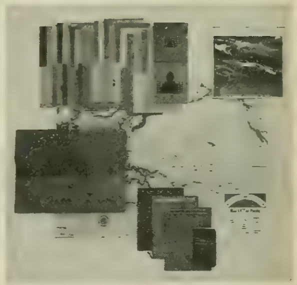

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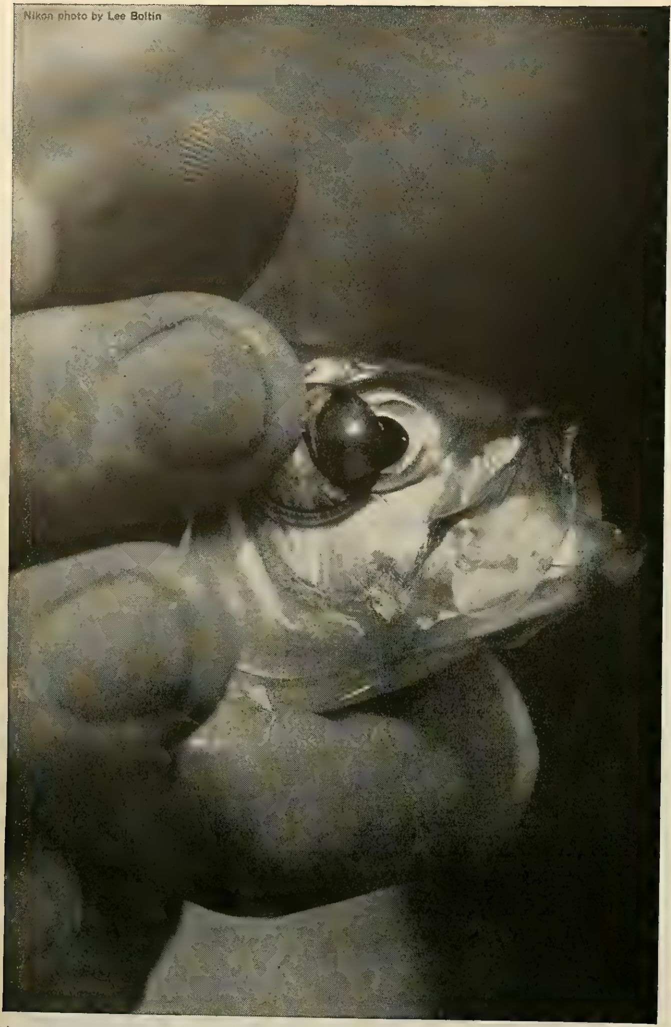

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tory Press)—the story of oceanography. On first glance this book is visually confusing. The illustrations are a stylistic potpourri, ranging from simple line sketches to elaborate, three-dimensional drawings of the sea, to a series of colored photographs. On the positive side, I hopefully believe each illustrative style was selected to elucidate a specific point. On the negative side, the stylistic profusion is overwhelming and unfortunately tends to make the book appear like the Great White Way—far too many flashing lights.

The writing is marred by unevenness—simplicity in some explanations, complexity in others—and is patronizing throughout. The technical information is generally correct, and the usual subjects are covered: waves, bottom contours, currents, minerals, the food chain. It is obviously a learned work based on many hours of reference library research.

On the other hand, *The Secrets of the Dolphin*, by Helen Kay (Macmillan), is a lovely book that presents these marine animals warmly, and does not resort to humanoid analogy. The small anatomical differences among the types of dolphins and porpoises are described, as are courtship, birth and maternal care, swimming behavior, and sonar communication. Myths and delightful stories are also included. All of it makes enchanting reading. The book is filled with accurate biological detail and presents up-to-date information on modern dolphin research. Most important, while the reader is captivated, he learns. This is a splendid book, and the photographs are excellent.

We leave the sea and go to five books about birds. The first, by the famous amateur ornithologist John Kieran, is called *An Introduction to Birds* (Doubleday), and the illustrations are by Don Eckelberry, who has had considerable experience in bird painting. The approximately one hundred birds mentioned are not presented in the usual classification, but rather in the order in which bird watchers are most likely to find their quarries, starting with the robin and ending with the eagle. Habits of each bird are described—some in greater detail than others. The lengthier descriptions include nesting habits and brood sizes; the rest give primarily anatomical details and general habitat.

This is an example of ordinary material, organized differently from standard bird books. Although there is an index, the volume is designed primarily for the beginning bird watcher who wants to find a species name by browsing through the pages. It could be a handy, instant reference work.

*The Gull's Way*, written and illustrated by Louis Darling (Morrow), is another example of the exquisite writing of this author. It is a poetically presented story of his observations of life in a gull colony on a remote island in Maine. Adding to its beautiful prose is a series of excellent color and black-and-white photographs, plus charming drawings of gull behavior. The photographs of the appealing young, particularly, are superb.

The reader who wishes to know about the significance of certain types of gull behavior and calls can find simple and direct explanations here. This book will undoubtedly come into greater usage as an interested observer sees more and more gulls on our beaches. Present-day environments, with their polluted waters and expanding garbage dumps, are providing favorable conditions for the expansion of the Herring Gull, to the probable detriment of other shore birds.

*Wonders of Hummingbirds*, by Hilda Simon (Dodd, Mead), is an improvement on a book by the same author, which was reviewed here several years ago. Miss Simon, who also did the illustrations, has moved away from explaining behavior as occurring through mysterious instinct, toward more acceptable biological fact. I am not sufficiently familiar with hummingbird classification to evaluate the scientific accuracy of some of her statements on distribution and identification.

My general impression is that the book does not quite come off. It does not give a true picture of the hummingbirds' vitality or coloring. The latter, like their evanescent movement, is lost in the colored line drawings, for it is the iridescence of the birds that makes them especially exciting. Color photographs would have captured these qualities much more effectively.

In *Birds and Their Beaks*, by Olive L. Earle (Morrow), forty-five examples give the budding biologist some idea of the wide variation in beak structure and in the resulting feeding habits of birds. Bird beaks are of many types, from those that can handle any kind of food to those that are highly specialized. The author has provided profuse and attractive drawings, but some scientists—and even non-anthropomorphically minded nonscientists—will chafe when reading that birds are "he" or "she" instead of "it," the more proper pronoun.

The beaks of the toucan, spoonbill, curlew, and hummingbird are a few examples of the range covered within the pages, and each description is accompanied by some pertinent information about the natural history of the bird.

*A Bird is Born*, by E. Bosiger and J. M. Guilcher, has photographs by Eric Hosking and R. H. Noailles (Sterling). The first section begins with an unpardonable statement—that the nucleus of the egg is transformed into a baby bird by the warmth transmitted to it by the brooding mother. The warmth is essential, of course, but for some reason it was not mentioned that fertilization is imperative. Even though this is a book for children, it is inexcusable for the authors to give the impression that the mere act of sitting on an egg will hatch out a bird.

In the first section, the photographs of how the single cell is transmuted into a chick are unclear and difficult to follow. Line drawings would have been superior. The second section contains a series of photographs that trace the posthatching development and parental care of altricial and precocial birds—those that emerge from the egg relatively undeveloped and those that emerge in a relatively advanced state. The reader will find that the photographs accompanying the second part are of better quality and the explanations clearer.

The step from birds to animals could be made in two amusing books about zoo keeping. The young man or lady who has a predilection for collecting will discover that there are ways to handle this urge. They can either find zoos willing to take the specimens, as did the Newmark twins, John and George, in *To the Zoo in a Plastic Box* (Random House), or set up their own zoo, as did Gerald Durrell in *Menagerie Manor* (Viking).

In both cases, the act of collecting is filled with humor, anxiety, small catastrophes, and frustrations, but never with misgivings. Mr. Durrell is an experienced and polished writer, and his is the more witty book of the two, but the Newmarks also have an interesting tale

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to tell about their collecting experience.

As mentioned earlier, I have found in the past, and still find, relatively little value in compilations about assorted animals—those in which the thin thread of relationship is derived from the flimsiest material. There is no way to tell by most of the titles just what such books contain.

Take Walt Disney's *Wonders of the Animal World*, for example, with its text by Vezio Melegari (Golden). In the table of contents, there is a new system of classification; animals are grouped as the strange ones, the predatory, the peaceful, the mysterious, and the elegant, to name a few of the new higher categories. At least sixty vertebrates are featured, and many have had parts in one or another of Mr. Disney's films.

The text is straightforward, but this book is for incidental reading. It may perhaps serve as an hors d'oeuvre to whet the appetite for studies in greater depth. It has an index, and the photographs are excellent—probably the reason for the book's existence.

Another collection, *Never Pet a Porcupine*, by George Laycock (Norton), is based on newspaper and magazine articles. Mr. Laycock tells about animals in a flippant, reportorial style, and he describes owls, squirrels, crows, foxes, field mice, ladybirds, pheasants, skunks, and, of course, porcupines. Most of the chapters contain anecdotes on the cuteness or cleverness of these beasts, plus a few facts about their natural history—some of which surprised me, such as that foxes so enjoy being chased by dogs that they keep on running just to keep the hunt alive. Twenty-two animals are discussed, with many of the articles directed toward people who live on farms, to show how certain animals can be useful in pest control and how others can truly be pests. Mr. Laycock encourages conservation—wherever he feels it is important. But there are so many similar books, based on collected animal stories, that I can't imagine what the contribution of this one might be.

Although *The Mystery Monsters*, by Gardner Soule (Putnam), is also a collection, it gets off the hook of the prosaic and pedestrian by compiling a novel assortment, ranging from bacteria to whales. The theme is the investigation of unusual, rare, or little-known animals, such as the blue whale, wild dog, marsupial "cat," manta ray (why should the manta's tail be so important for propulsion, Mr. Soule, since its powerful pectorals are capable of carrying it forward?), electricity and the eel, turtles, sunfish, and the giant clams. Some of the reporting is based, evidently, on personal interviews with scientists working on the problems, some on popular science articles. The last chapter is on some of the many unsolved problems in biology.

The book will probably not be used as a reference source, with the exception, perhaps, of the good bibliography, but it should arouse curiosity among young readers and provide them with the feeling that they, too, will find problems to solve if they choose biology as a career. Solving some of those problems, as presented within these pages, can result in experiences that are both exciting and hazardous.

The worst offender of collected animal stories is *Everyday Miracle*, by Gustav Eckstein (Harper & Row). It is unscientific, the interpretation of behavior is entirely inaccurate, and it should not be grouped among books on science. If Dr. Eckstein is a physiologist, he should stick to it and stay out of behavior. I shudder when I read of animals with souls. I thought this kind of thinking disappeared in the eighteenth century.

In sharp contrast is *All About Elephants*, by Carl Berger (Random House) —a fine book, with an introduction by Fairfield Osborn, President of the New York Zoological Society. Without any anthropomorphic clichés, the author conveys a feeling of warmth for these huge animals of Africa and Asia, and he traces vicissitudes in the lives of three individuals. One lives wild in the forest; another is a work elephant; the third is a circus performer. The reader will discover how an elephant is trained through constant repetition, and that it can learn a remarkable variety of activities if the trainer is patient. The drawings and

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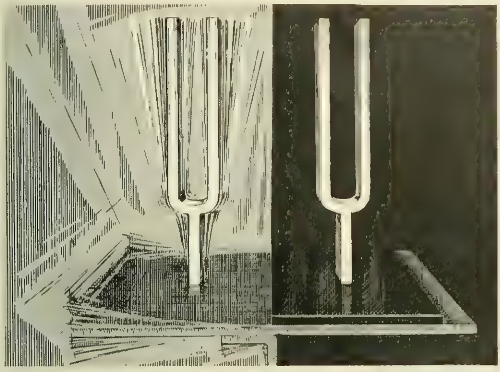

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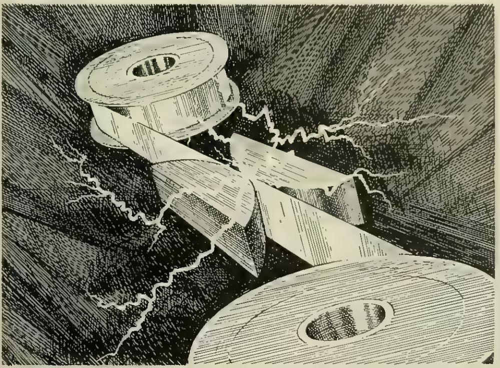

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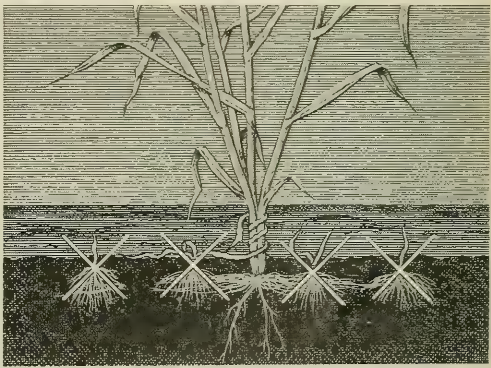

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the photographs are all outstanding.

*The World of the Raccoon*, by Leonard Lee Rue III (Lippincott), also demonstrates how interestingly animals can be presented. The highly readable biological descriptions and the excellent photographs by the author contribute to an understanding of raccoons—among the most interesting of the carnivores.

Amateur naturalists who are captivated by these attractive animals will find answers to a large number of questions, concerning such varied subjects as the animals' geographic range, how large they grow, what they eat, and their life cycle. This is enhanced by a good bibliography and an index.

*Our Fellow Immigrants*, by Robert Froman (McKay), deals with a fairly unusual subject—that many animals with which we are familiar are relatively recent imports to the United States. Many readers will be surprised to learn that the horse evolved in North America but then disappeared in the Pleistocene and finally was brought to the continent by the Spanish conquistadors. The author interweaves human history with animal immigration when he describes the historical introductions of domesticated animals such as cats, dogs, cows, and the not-so-acceptable "domesticated" creatures—rodents and cockroaches.

Even some failures, such as the inability of camels to survive here, are included. The subject is topical and important because scientists are now discussing the pros and cons of animal introduction, and the effects of such introductions on the ecology and survival of native species with which the introducees will compete.

*Animal Ancestors*, by Sonia Cole and M. Maitland Howard (Dutton), has a misleading title because it is really about mammalian ancestors—quite a different thing. The straightforward descriptions of anatomy and fossil history are largely accurate. If the authors had stuck with this approach, all would have been well. But they seem confused about fundamentals of evolution and of genetic variation, although, on first reading, the statements appeared acceptable. It is the juxtaposition of certain phrases and some Lamarckian inference that weaken the usefulness of this book as a primer in mammalian evolution. The authors state that enterprising animals changed, while timid ones altered very little. Nonsense! Throughout, there is an undercurrent that indicates evolution came about as a result of needs of the animals. I'd like to give examples of contorted thinking on this subject. "When an animal runs swiftly, it touches the ground with only the tips of the toes; and so in the course of evolution, the number of toes was gradually reduced from five and the central one (or the middle pair) was strengthened," and "As they took to eat-

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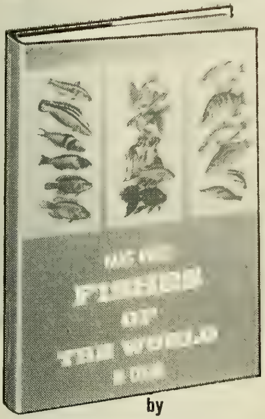

by

**HANS HVASS**

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ing coarse vegetation, their molars and premolars grew larger to give an increased grinding surface."

Perhaps for a slightly younger group than junior high school is Millicent E. Selsam's excellent *The Courtship of Animals* (Morrow), which is up to her usual highly competent standards. On a sound biological basis, it describes courtship in various animals from fishes to mammals, and adds some details on insects and spiders. The significance of some of the behavior is also explained. I can recommend this book highly.

*Watchers, Pursuers and Masqueraders*, by Edith Raskin (McGraw-Hill), attempts to cover a vast field of animal behavior and animal adaptation. The main theme is the visual system of vertebrates and several invertebrates, and the relation between visual capacities and behavioral activities. The information is up to date, with much of it gleaned from current research, but the book suffers from a "too muchness" quality. In the brief 150 pages, vision or camouflage is described in approximately 200 animals, with the result that the reader is overwhelmed by the profusion of information. If the author had selected only vision as a theme, developed it in greater detail and in fewer animals, the book would have been a more positive contribution. As it is, the survey is necessarily shallow, but perhaps even the excess of information will open the eyes of some readers. Vision is a fascinating topic and not too often treated by writers of children's books.

Perhaps the most exquisite of all the books I have studied for this review is *African Wildlife* (Viking). The English text is translated by Nieter O'Leary and Pamela Paulet, with photographs selected by Franz Roedelberger and Vera I. Groschoff. Upon first perusal, one is struck by the most unusual and truly magnificent photographs, which come from many sources. This would be a stunning book to find under the Christmas tree.

The largest section is on mammals, but there are also excellent photographs of birds, insects, reptiles, amphibians, and fish. A concise and informative text describes the photographs. Throughout, even while discussing habits and habitats, the authors put great emphasis on conservation, and the reader becomes abundantly aware of how much mankind loses through thoughtless or uncontrolled slaughter. There is a description of the Serengeti, which a number of scientists are now attempting to make into an ecological research station. I unreservedly recommend *African Wildlife* as a book to own, not only for its splendid photographs, but for its effectiveness in showing just how marvelous that wildlife is.

A more generalized approach to the natural sciences can be found in *All About Biology*, by Bernard Glemser

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(Random House). This book has a presumptive title. It is not "all about" biology, but deals with one small part of it. It is for fifth- through seventh-graders, and is concerned with the beginning of life, describes some of the experiments in which amino acids were created from water, hydrogen, ammonia, and methane, and postulates how the first substances of life could have been formed. It then goes into the development of microscopy up to the electron microscope, and thence to some descriptions of the amoeba, paramecium, hydra, earthworm, and then, abruptly, of man. Although its title indicates a more grandiose work, it has merit in that it brings to young students relatively new areas of research, and makes them aware of current and fascinating discussions on how life may have originated on our planet.

In *Triumphs of Modern Science*, by Melvin Berger (McGraw-Hill), there is emphasis on the individual's participation in scientific discoveries. (Actually, I would like to know what prompted some of the inclusions as part of modern science, unless by "modern" the author means anything between 1900 and 1960.)

Each chapter is a biography of the scientist identified with a particular discovery, and includes the histories of penicillin, viruses, antibiotics, X-rays, DNA, radioactivity, and relativity. I like the human element in this type of reporting, because I think that young readers can relate to it and see the possibilities that exist for their own achievements in science studies. However, I wish the author had emphasized somewhere that many discoveries are not made suddenly, but usually have, as a foundation, years of work carried out by many people and leading to one individual's spectacular "breakthrough."

The writing is clear and expository, and there are suggested lists for further reading at the end of each chapter.

DNA remains topical. It is important that discoveries of such profound importance are being presented to the young science reader. A new book on the subject is by Edward Frankel and is called *DNA—Ladder of Life* (McGraw-Hill). It is as up to date as one can be with DNA, for even at the moment a book on this subject is published, new discoveries are being made. It appears to be a competent work and should provide a reference source to high school students, but it contributes little in originality.

*Chemistry of Life*, by Katherine B. Hoffman and Archie L. Lacey (McGraw-Hill), is part of a series called "Vistas of Science," conceived by the National Science Teacher's Association. The series will be useful to students who are considering going into science, for the books describe specific careers—in this case, biochemistry.

The introduction, concerned with the research activities of a biochemist, is one of the most lucid explanations I have read in a long time, and the book makes the subject seem intensely interesting. Students who use this as a source of reference will not be overwhelmed or confused, as they so often can be after reading difficult subjects written for those who have insufficient technical background. Studies of energy cycles, photosynthesis, cell metabolism, RNA, and DNA are a few of the areas encompassed by a biochemist's work, and the latter part of the book contains experiments in biochemistry that students can do in their school laboratories. There is a selected list of reading, which contains the names of some outstanding biochemists, a glossary of terms, and an index.

There are only two insect books under consideration this year, and both are remarkable. First is *A Butterfly is Born* (Sterling), by J.P. Vanden Eekhoudt—one of the Sterling Nature Series. The illustrations are lovely, and each is clearly explained. The book is, in fact, essentially illustrative, with biological information given in the captions through some of the clearest writing I have ever seen in a book for young people. The graphics could well be a model for museum exhibitions, for the drawings are perfectly clear, the author's photographs are superb, and the accompanying labels cannot be misinterpreted. Here is an example of how visual material in a book can be utilized effectively in such a way that the text does not repeat what is apparent in the photograph, and the photograph clarifies considerably what might require a much longer explanation in the text. I think it compares favorably with *A Bee is Born*, one of the earlier books in the series, which I also found an exciting visual experience.

*A Butterfly is Born* includes the life cycle of these insects from caterpillar to chrysalis to the final emergence of the adult. All in all (at the risk of repetition) a book to own.

Last is *The Story of Ants*, by Dorothy Shuttlesworth and Su Zan Noguchi Swain (Doubleday). This is a work of art. The illustrations are enchanting and original, and even if one does not wish to read the fine text, just to turn the pages is a treat. Accompanying the beautifully executed paintings, essentially in soft browns and yellows, of a number of greatly enlarged ants, are life-size silhouettes of the same species. Army ants, carpenter ants, harvester ants, honey ants, and ant societies are described. The prose is excellent, and the author includes a simple and inexpensive technique for constructing one's own observation ant nest. After they have read this book, I think many people, adults included, will eagerly undertake the maintenance of such colonies.

EVELYN SHAW

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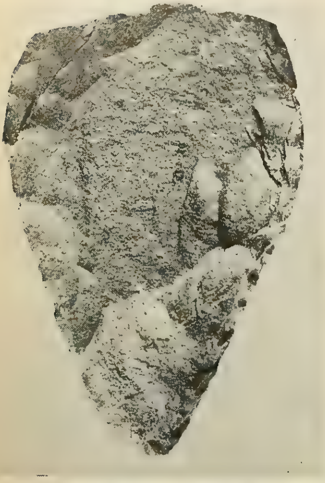
# Search for Greece of the Stone Age



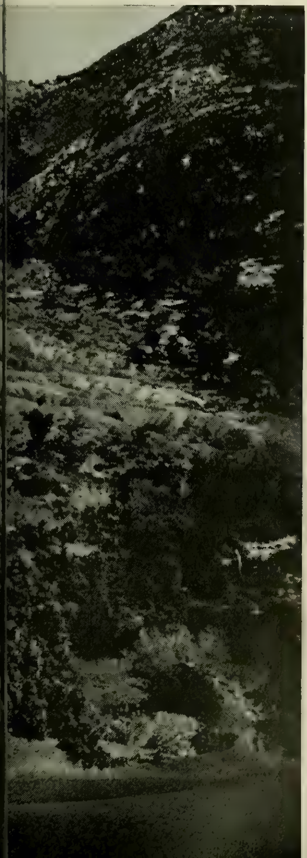
### By E. S. Higgs

Perhaps to most people Greece is an archeological mecca. There are few who would regard a cultural tour of Europe complete without a visit to Delphi, Athens, or Mycenae. Yet, just how complete is the archeological record of Greece? In 1923 Jardé wrote that not a single Old Stone Age specimen had been found in that country, and as late as 1948 the position had scarcely changed. Certainly a small Paleolithic site, the cave of Seidi, situated between Levadia and Thebes on the southern shores of ancient Lake Copais, had been discovered in 1941 during the German occupation. Its Stone Age tools, however, were few and not very informative. No further

**Oldest** known tool from Greece is an Acheulean hand ax 100,000 years old.

**Northward view** of the valley at Agios Georgios shows red clay deposit sites.

finds of interest were made until 1958, when a German expedition investigated a small quantity of Stone Age artifacts that had been washed out of the banks of the Piniós River. Excavation followed, but the rewards were meager. In fact, in 1960 the find of a single waste flake elsewhere in Greece was regarded as worthy of a professional report, although in the same year a fossilized Neanderthal skull that had washed into a cave in antiquity had come to light in Khalkidhiki. If this record is compared with that of France, the difference is immediately apparent. In France the discoveries of Old Stone Age sites occurred at an early date. In 1863, Edouard Lartet, a French magistrate, and Henry Christy, an English banker, began their Dordogne excavations, which established the evidence of Paleolithic man. It is perhaps appropriate that the publication of this first account of a Paleolithic succession in Greece should occur exactly one hundred years after the death of Mr. Christy.



Certainly, therefore, until the present series of investigations began, little was known of Greece before the Greeks and, as a result, virtually nothing of the background of Greek civilization. In recent years, Robert Rodden of Harvard proved that farmers existed some 8,000 years ago at Néa Nicomedeia. But man the toolmaker has existed for over 1,000,000 years—leaving a gap of probably more than 990,000 years. Moreover, innumerable archeologists have traveled extensively in Greece, but none of them had observed traces of Paleolithic man on Greek soil. The chances of a successful investigation, therefore, were apparently slight. Yet the fact remained that even during the ice ages, when the ice sheets covered a great part of Europe, Greece had a favored warmer climate that must surely have attracted human colonization.

Searching for Paleolithic sites is no easy task. There are no obvious features, such as walls, ditches, house foundations, or mounds of pottery, to guide the investigator. It is a matter of seeking day after day for a stone of a particular shape among the countless stones in the river gravels or high up on the mountainsides.

In 1961, I led a Cambridge team that began a search in Macedonia. The method was simple. Two Land Rovers proceeded along the roads and tracks of Greece, while six members of the party spread out and walked on either side. The vehicles scouted ahead for likely territory and occasionally returned to pick up the searchers for reports. We camped where we finished for the day and in this way sampled a considerable area of Macedonia.

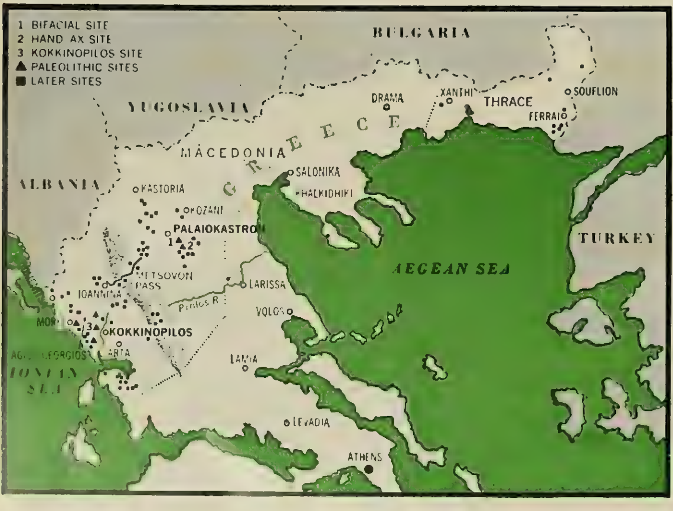
For fourteen days there were no finds, although, of course, other incidents occurred. There were regular attacks by the massive Macedonian dogs that guard sheep and goats. There was a roundup by police who were convinced our purpose was not legitimate, and one night a wolf killed a screaming donkey at the edge of the camp. Another day an army officer strolled out from a roadside café and advised us not to go on. "We are fighting the Albanians up there," he said. "The frontier is not agreed upon and it is where the Greek general of the day says it is."

On the fifteenth day the first stone implement was found—a flint flake beautifully worked in the form of a trapezium. It was similar to those found at Néa Nicomedeia with the evidence of the early farmers. The search was intensified, but there were no further finds in this locality.

We then decided to move to Epirus, some seventy miles over the Metsovon Pass. This dramatic road winds over the Pindhos Mountains, the backbone of Greece, through rugged country where a level area and a spring have determined the location of each village. In the low-lying areas the vegetation is luxuriant where there is water and entirely absent or of the scrub type where it is dry. As the road rises to higher altitudes, there is a coniferous forest interspersed with cool-temperate grasslands. This vegetation in all probability descended to the lowlands during a period of glaciation. It is the pollen from this type of plant that we expect to find buried deep in the peat swamps and lake deposits of the present-day arid areas, indicating that during a cool climatic oscillation of the Würm, or last, glaciation in Greece the plants spread to these now-arid regions. For this reason many days were spent in Epirus taking samples from borings into ancient lake deposits to ascertain, from the presence of these pollen grains, something of such oscillations. In these upland areas, the black-skirted, seminomadic Vlachs still practice the ancient custom of transhumance—pasturing their flocks and herds in the highlands in summer and returning to their deserted villages in the lowlands before the first winter snowfall. This relic of an ancient culture is not without its archeological significance, for the Vlach way of life may well be the same as that of the first farmers in Greece.

In Ioannina, the capital city of Epirus, we found many flakes made of chert, a metamorphosed limestone. They were obviously of recent origin and resulted from the shaping of chert blocks for house building. This stone is sufficiently homogeneous to fracture in a predictable way, and was therefore a material much favored by Paleolithic man for toolmaking. Here, at least, we had discovered an area in which suitable raw material existed. Further, outside the city is the large Perama cave, noted for its stalactites and its fossilized wild animal bones. Outside the cave we found a single struck flake patinated a yellowish white, which indicated a considerable antiquity, but again no additional

**Middle Paleolithic** tools were found in excavations in Agios Georgios clay.


1 BIFACIAL SITE
2 HAND AX SITE
3 KOKKINOPILOS SITE
▲ PALEOLITHIC SITES
■ LATER SITES
BULGARIA
YUGOSLAVIA
DRAMA
XANTHI
THRACE
SOUFLION
FERRAI
GREECE
MACEDONIA
ALBANIA
SALONIKA
KASTORIA
HALKIDHIKI
KOZANI
PALAIOKASTRON
TURKEY
METSOVON PASS
IOANNINA
LARISSA
Pinios R
AEGEAN SEA
VOLOS
KOKKINOPILOS
ARTA
AGIOS GEORGIOS
IONIAN SEA
LAMIA
LEVADIA
ATHENS

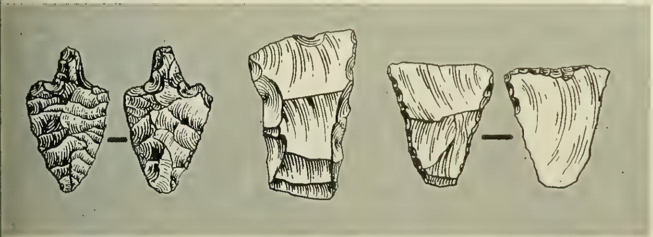
**Hand ax sites** may indicate a ring of Lower Paleolithic axmakers around the Mediterranean. Palaiokastron was place where the ax on page 18 was discovered.

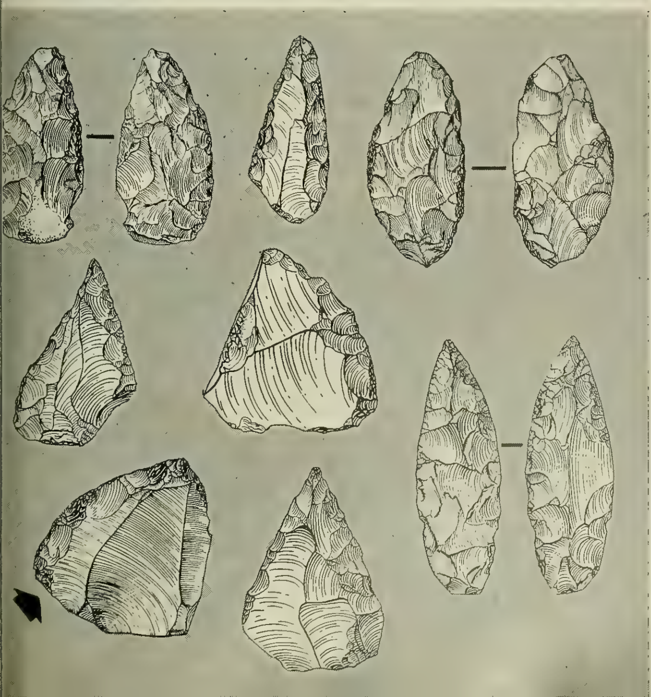
**Neolithic** and Bronze Age points, *top right*, were surface finds. Agios Georgios clay yielded rest of points, including one (arrow) that led to chipping floor.

finds were made either in the cave or in its vicinity. At the entrance to the cave there is a concrete floor, placed there for the convenience of visitors wishing to see the stalactites and stalagmites. It is under this floor that one would be most likely to find Paleolithic remains.

Around the great lake of Ioannina there are low hills, and while they yield many workshop floors, we judged the few finished artifacts to be of a late date—perhaps *circa* 4000 B.C. A reconnaissance to the west, toward Igoumenitsa, produced a number of chipping floors belonging to Late Neolithic and Bronze Age times. The drawings, *panel below*, show beautifully made, tanged, and chisel-ended arrowheads common along the valley of Kokkitos. Curiously, these ancient sites showed no sign of pottery, so it may be assumed that they indicate the presence of wandering bands of hunters (the indigenous people certainly made pottery). In Neolithic times, the valley of Kokkitos, with its swamps and lakes, must have been a prolific hunting ground. The Old Stone Age, however, still evaded us.

Our first piece of good fortune came three weeks after beginning the search. Between Ioannina and Arta is Agios Georgios, a village with a torrential spring, the waters of which were once led by aqueduct across the Louros Gorge to the classical city of Nikopolis on the coast some twenty-five miles away. The ruined aqueduct still stands. Here a goat path leads up the cliff face. Beyond, a great basin rimmed by mountains has, at some time in the past, been filled in by windblown dust. This dust was probably derived from an extensive foreshore that existed during a low sea level when, during a glaciation, a great quantity of water was locked up in the form of ice at the poles. The dust is now compacted into a red clay some seventy feet deep and is being eroded away in great channels and gullies. The red clay surface is without a cover of vegetation except for a few scrub bushes that still remain on small, level areas of an old land surface. In one gully I found a Middle Paleolithic type of point, characteristic of tools made by Neanderthal man. It was in mint condition, and had obviously been protected throughout its existence, but it was brittle and fragile, for chemical changes had almost completely altered the physical character of the original stone. The presence of Stone Age man had been established.





Clearly, the point had only recently been washed out from the soil; otherwise, in its fragile condition, it would have weathered or been damaged. Therefore, we believed there would be more wherever it had come from. The gully was followed up and more pieces were found. When they ceased, we scratched the sides of the gully with trowels and found a number of embedded points. This had probably been a chipping floor some 40,000 years ago. Subsequently, thousands of tools were found in this circumscribed area of about a mile by two miles.

Since so many artifacts had been found here, it seemed unlikely that there should not be other sites in the neighboring valleys. What was the extent of the Neanderthal occupation in Greece? The search was transferred to the next valley, but only a single Stone Age implement was found. It had, however, been washed out of a small pocket of the same kind of red earth as that in the previous valley. The soil on most of the mountains of Greece is being eroded away, and there are many "ghost" fields—remnants of an earlier agriculture—now too barren for further cultivation. It occurred to us that the pocket of red earth might be the remains of an early land surface on which Mousterian man had lived, so we began a search for patches of red soil rather than for artifacts. Fifteen patches of red soil yielded Middle Paleolithic sites, including one at Morfi. Some patches are large areas hidden in mountain basins; some are small—only a few square yards—and still cling to the hillsides.

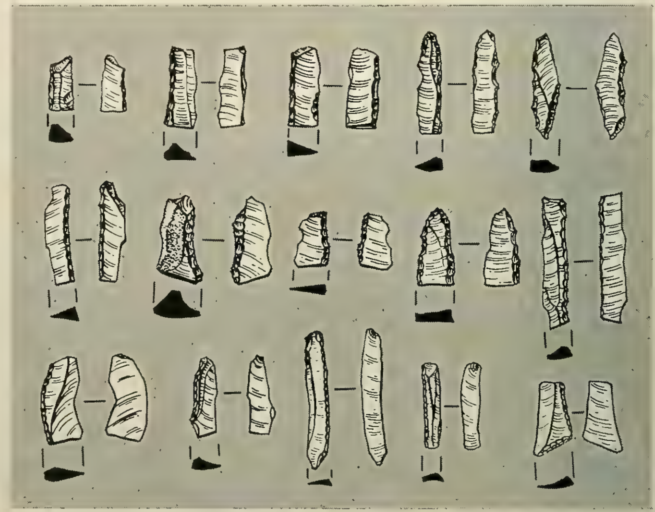
In 1963 the chipping floor found the previous year at Kokkinopilos was excavated, and a trench was cut into the red clay. Many varieties of tools were found, including D-scrapers, a bifacially worked lancehead, and some Mousterian-type side scrapers and points. It is thought that these lanceheads are similar to those that have been recognized in the eastern German highlands and that they may represent a contact between the two areas, although in other respects the two cultures are not similar. There were also many tortoise cores, so called because of their shape. The flakes were shaped before being struck off the parent core—a record of prefabrication dating back 40,000 years and more.

The red clay overlies a breccia (a cemented layer of frost-fractured stone fragments), which is usually caused by conditions of extreme cold. The red clay, therefore, is younger than the glacial temperatures that formed the breccia. On top of the clay, in turn, a scree (loose rock fragments) has fallen in places adjacent to cliff faces. Scree, also usually the result of cold conditions, has not formed in this area recently. It is therefore concluded that the red clay and its attendant implements were probably deposited between two cold phases of the last glaciation. The last cold period likely to have affected this southern area began about 30,000 years ago; thus, the industry related to it could have taken place earlier. On the other hand, the upper scree could have formed as recently as about 12,000 years ago.

In the red clay, well above, and therefore later than, the "Mousterian" levels, some tools of the type made by *Homo sapiens* were also discovered. These could also be more than 35,000 years old, and if so, are perhaps the earliest known evidence of modern man in Europe. This still requires verification, but the clay does contain a quantity of small-backed blades that are similar to those found at a number of Russian sites on the Dnieper and the Dniester rivers and known to be older than 24,000 years. When carefully excavated, the chipping floor showed waste material from stone tool manufacture, clustered on the bottom and sides of an ancient gully.

When we crossed back over the Pindhos Mountains, still in 1963, some high-level gravels, about 400 feet above the present valley bottoms, were noticed at Palaiokastron, near Kozani. Here was found the oldest tool so far known from Greece—an Acheulean hand ax, perhaps 100,000 years old (*see page 18*). Current theory—based on the rarity of hand axes east of the Rhine and Italy—has supposed an invasion of hand-ax makers from Africa into Europe across the Strait of Gibraltar. Another wave of these peoples passed east of the Mediterranean Sea to Mount Carmel, but a lack of evidence in the Balkans led to the supposition that these were two independent invasions. The find in Greece, however, suggests that there was a ring of Lower Paleolithic hand-ax makers around the Mediterranean. The Palaiokastron hand ax is made of green trachyte, and is in excellent, unworn condition.

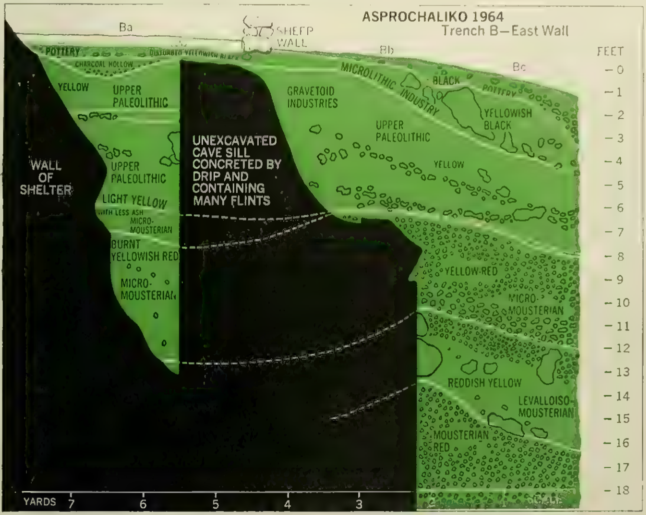
Obviously, more research was required. There was still a gap in the succession between 35,000 and 8,000 years ago. In addition, many more general questions remained to be answered, for the archeologist is concerned not only with the tools Stone Age man made but also with his reaction to climatic and environmental



**Small-backed blades**, *above*, were in red clay under glaciation scree, *below*. Their age is not determined, but they bear strong similarity to tools found at Russian sites; latter are known to have been made over 24,000 years ago.

changes. For example, a change in the fauna of the area not only reflects a change of diet; it demands an adaptation of man's hunting methods, his economy, and perhaps even his beliefs and the organization of his social structure. The most suitable site in which to find answers to these questions is a cave, because it provided a convenient place to live, not merely a workshop chipping floor. Here may be the remains of habitation from succeeding cultures — the remnants of meals, including the bones of the eaten animals. These may well indicate climatic changes, for animals often are adapted to limited environmental conditions. Charcoal from hearths, as well as the animal bones, may provide material for more accurate dating by the radiocarbon method. In 1964, therefore, we began a search for a suitable cave. There are not many in the area, and most of the existing ones have bare bedrock floors with no deposits on them. Two, however, contained deposits, and we excavated their entrances. Paleolithic man did not, as a rule, live inside caves, but at their entrances. Trenches dug outside one of the caves, however, soon revealed stalagmites that had obviously been formed by drip from the roof, which had collapsed long ago. The entrance to these linked caves had disappeared, and the valuable deposits had washed away. At the bottom of the other cave, however, stalagmites had also formed —and stalagmites are not being formed at present. Fortunately, stalagmites can be dated by the radiocarbon method, and it is hoped that testing will permit dating of an early, wetter, and perhaps colder climate in Greece.

As these caves had probably collapsed as the result of an earthquake, and as this area of Greece is known to be tectonically unstable and must have suffered innumerable shocks, we turned our investigations to rock shelters. These are not easy to find. They are only shallow concavities in cliff faces and are often filled with detritus. However, herdsmen in Greece take advantage of the natural characteristics of the area and utilize such sheltered places for goat pens by erecting a semicircle of boulders and thorns. Eventually, one was found that faced south. Protected from northern winds and in the sun, it would have been warm in winter. It is in a narrow ravine that would have provided an excellent game trap, and the nearby Louros River would have supplied water and fish for the inhabitants. This shelter, it has been found, is the oldest known habitation site in Greece (*photograph, page 25*).


ASPROCHALIKO 1964
Trench B—East Wall
Ba
SHEEP WALL
Bb
Bc
POTTERY
DISTURBED YELLOWISH BLACK
CHARCOAL HOLLOW
YELLOW
UPPER PALEOLITHIC
WALL OF SHELTER
UPPER PALEOLITHIC
LIGHT YELLOW
WITH LESS ASH
MICRO-MOUSTERIAN
BURNT YELLOWISH RED
MICRO-MOUSTERIAN
UNEXCAVATED CAVE SILL CONCRETED BY DRIP AND CONTAINING MANY FLINTS
GRAVETOID INDUSTRIES
MICROLITHIC INDUSTRY
BLACK
POTTERY
YELLOWISH BLACK
UPPER PALEOLITHIC
YELLOW
YELLOW-RED
MICRO-MOUSTERIAN
REDDISH YELLOW
LEVALLOISO-MOUSTERIAN
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YARDS
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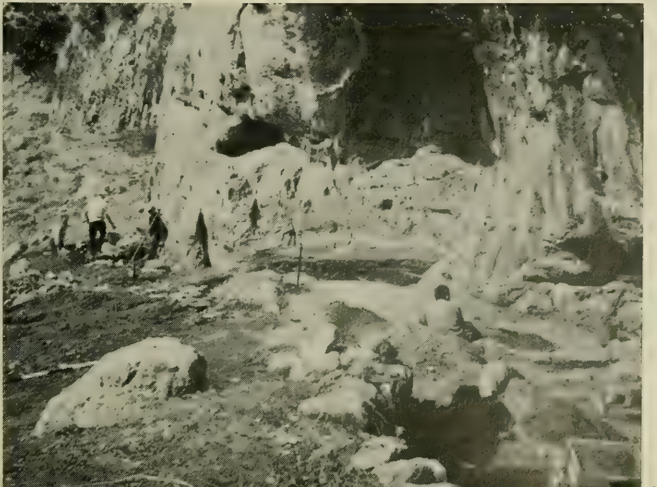
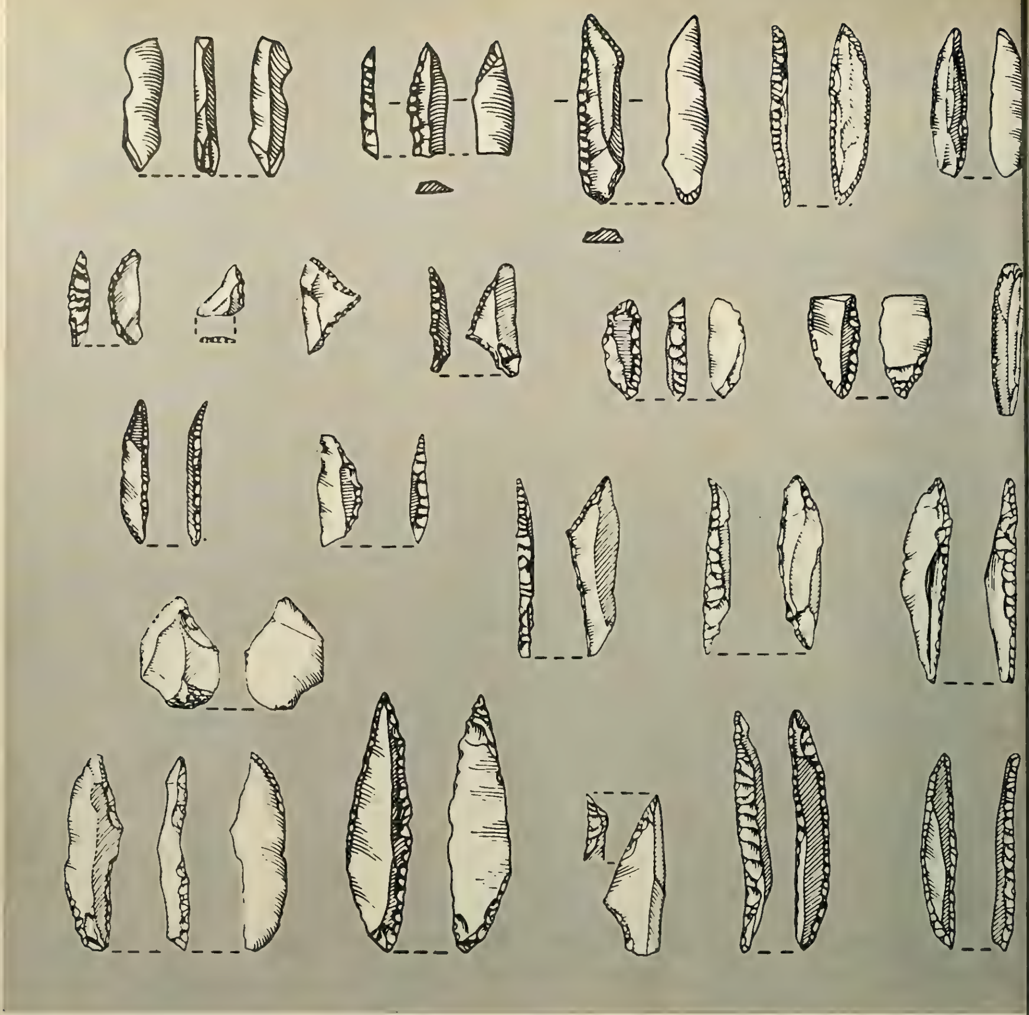
3

**CROSS SECTION of dig at Asprochaliko, which means "white stone chippings," is seen, *above*, with periods indicated.**

**Trench in shelter floor, *below*, was site of thousands of tools of various types, as well as many animal bones.**



THE shelter, known locally as Asprochaliko, which means "white stone chippings," is 98 feet long and 46 feet wide. In order to disturb as little of the deposit as possible, we cut a trench only 5 feet wide (*left*). Below a surface layer of dung we found a series of hearths with prehistoric pottery. Below this level was a fine, yellow deposit, stained black by the overlying dung and humus, in which were thousands of worked flints, evidence of an intense occupation. The tools were of many kinds: minute flint triangles, not more than one-quarter of an inch long, carefully trimmed on two sides; crescent artifacts; and burins, or gravers, which are known to have been used for engraving the walls of caves and grooving bones and antlers in the manufacture of tools. There were many implements for scraping the fat off skins before curing them, shouldered points, so called

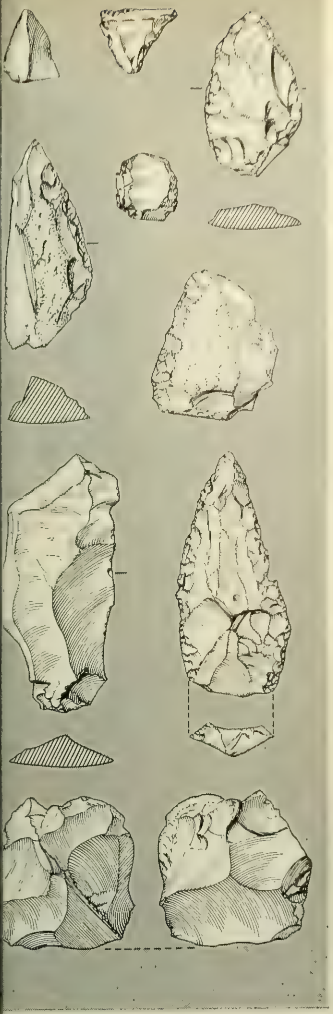


because they are worked to form a projection on one side, and a variety of long, narrow, bladelike artifacts blunted down one side. In western Europe these latter tools, fastened to the sides of arrows with gum, provided a sharp cutting edge. This collection of tools is remarkably similar to one from the upper layers of a cave named Romanelli, which lies across the Strait of Otranto and is radiocarbon-dated at about 12,000 years ago. It is clear that this was one of the last hunting cultures in this area around the Adriatic, and suggests a new industrial province covering at least a part of Italy and Greece. There were also quantities of deer, bear, and wild goat bones, indicating the people's diet.

At about five feet from the surface and below the stained-rock zone, the industry showed change. There was still a fine-grained, yellow deposit, but some of the tool types were no longer present. Geometric forms were not made in these earlier times, and the industry then consisted primarily of backed blades.

There was again a change at about eight to nine feet from the surface. A prolific but crude industry was present in considerable quantity. There were no backed blades, and only small implements of the Mousterian type, such as side scrapers and small tortoise cores. Such micro-Mousterian industries, named from the small size of the tools, are known from a few apparently unconnected sites. There are some in Italy, in Yugoslavia, in the Levant, and in Tripolitania in North Africa. Their significance is not well understood, and so far no human remains have been found with them.

Twelve to eighteen feet from the surface was still another industry. These tools are large and consist of heavy side scrapers, Mousterian points, D-scrapers, and flat cores. This is similar, in some respects, to the Levalloiso-Mousterian industries of North Africa and the Levant, and is of the type already found in the red earth at Kokkinopilos about two miles away. In these deposits we found bones of bear, deer, and a now-extinct rhinoceros, which show that these animals formed



Upper Paleolithic points on opposite page were found in top layers at the Asprochaliko site. The four tools at the top, immediately to the left, are micro-Mousterian, and the rest are of Levallois-Mousterian type: these are also from Asprochaliko, *below*, which is oldest known Greek habitation site.

part of the regular food supply of the early hunters. The bottom of the deposits has not yet been reached.

It may well be, therefore, that the object of our investigations has been largely achieved and that with some further study of the material, the industries and the environment of Greece over the last 40,000 years will be established. The future of Epirus for further Paleolithic studies is assured. It may be that cave art will be discovered in Greece for the first time, and deposits may also contain skeletons of extinct Neanderthal man.

Most fortunate of all, scientific methods are now sufficiently advanced to be used to the full in exploring an entirely new Paleolithic province.

# Giant Snail Is Used for

by CELSO PAULO JAEGER

Generally speaking, there are two ways of looking at animal diversity. One scientific method, that of the evolutionary biologist, tends to catalogue the multiplicity of species and study how they evolved structural, behavioral, and physiological adaptive differences. The other approach, used here, is that of the physiologist. Interested primarily in a process rather than a group, he searches for an animal whose structure or adaptation provides a particular system of organs in which the process that interests him may be examined with the greatest facility. Besides furnishing such an organic system, the animal to be studied must be easily available and possible to raise in the laboratory.

Recent work on muscles of vertebrates has brought new emphasis to the muscle types found in mollusks. Mollusks have muscles with various special properties, such as those that pull the snail into its shell and the adductor muscles that hold together the shells of clams, oysters, and scallops. The latter muscle is particularly interesting because of its plurality of function: some fibers must close the shells quickly when the animals are disturbed; other fibers must hold the shells together for relatively long periods and against a considerable pull.

Of interest here, too, is the capacity of some muscle fibers to respond in the same or in sharply distinct ways to diverse chemical compounds. Studies of such systems provide additional information about the mechanisms of muscular contraction and activation and permit bio-assay of diverse compounds of pharmacological interest.

The major adaptive radiation of mollusks occurred in the oceans. The vast majority of the larger and more easily usable species, therefore, are marine; this presents one disadvantage in collecting them for study. With few exceptions, the terrestrial forms are small: primary exceptions among the pulmonate gastropods (snails) are found in the African family Achatinidae and the South American family Strophocheilidae; these two families include the largest terrestrial mollusks in the world. The African species have developed into devastating agricultural pests, completely wasting some areas into which they were introduced. In contrast, the South American group may well furnish an important organism in the furtherance of physiological research.

The snail genus *Strophocheilus* (twisted lip) includes some forty-one species, widely distributed over South America, where they range from Panama to southern Argentina. The snail of prime interest for physiological studies is *Strophocheilus oblongus musculus* Bequaert, 1948. This is a common south Brazilian species that lives in rain forests and grasslands. It reaches population densities in excess of one specimen per five square feet, or almost ten thousand per acre. Adults have pink shells from two and a half to three and a half inches long, and the animal with its gray foot extended may exceed six inches.

These snails are most active at night, and may be found under fallen leaves, stones, or logs during the daylight hours. They are occasionally seen in the open during the day, since they creep out into the sunlight after showers have raised the humidity near the ground. In dry weather they burrow into loose soil to a depth of twenty inches, there retreating completely into their shells. They then

**After hatching** in a laboratory nest, young *Strophocheilus* eat shells, *above.*

**Adult snail** and single young search for tender shoots and leaves as food.

# Muscle Studies

secrete a mucous covering, or epiphragm, that closes the shell's aperture except for a small air inlet tube, thus reducing the rate of water loss during estivation.

The snails are hermaphroditic, and all individuals have both male and female sex organs. Here, as in many other such situations (theoretically deleterious), self-fertilization is impossible. Two different individuals still must meet and mate. During mating, each passes sperm to the female receptacle of the other specimen. Advantages of the system are that any meeting between two adult individuals may, in theory, lead to a successful mating and that each individual is able to raise a brood.

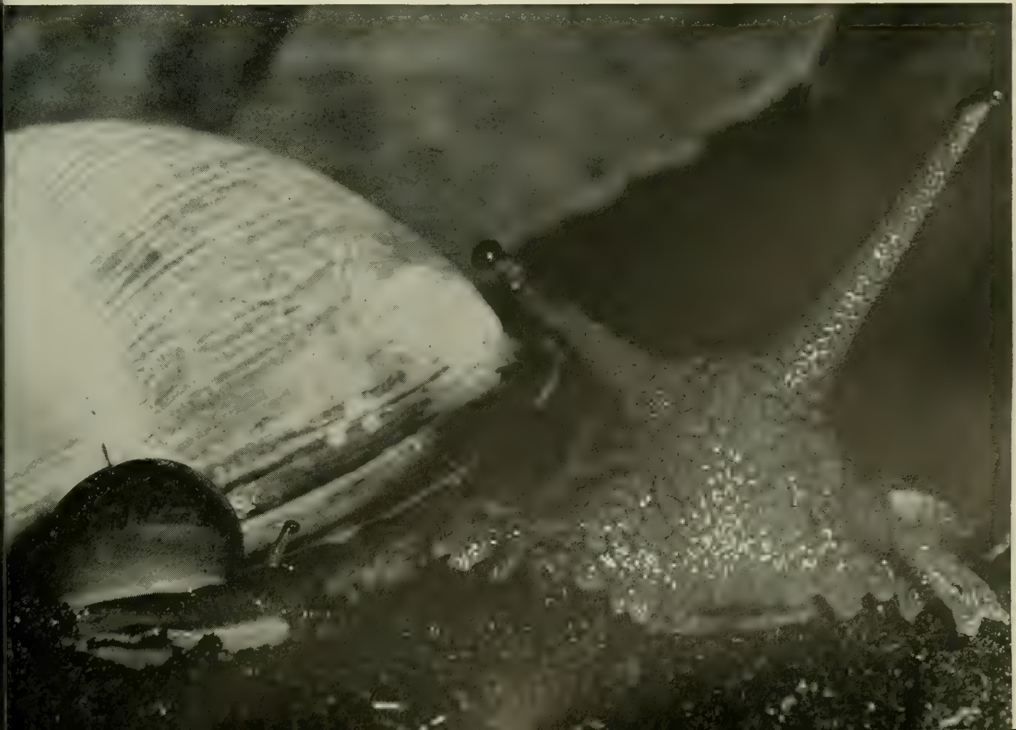
The eggs are laid in underground nests during the summer, and each nest ordinarily contains five to seven eggs. The mother's size determines the size of the eggs, but generally they are as large as sparrow eggs, for which they are often mistaken. Incubation takes about two months, and the young emerge from the shell as miniature adults. Their first and most calcium-rich meal is their own eggshell, after which they begin to feed on shoots and leaves.

The animals double in size during their first year, and it is believed that they require from three to five years to attain adult size. The greatest hazards to an individual's survival occur during this early period, for their most effective predators—lizards and hawks—feed mainly on younger specimens with thin shells.

It has recently been found that this species is easily raised in the laboratory. Captive animals will mate, and laboratory-born young are as active as those born in the wild. Because *Strophocheilus* may turn out to be a good laboratory animal for macro- and micro-anatomical studies and for physiological investigations, it seemed useful for some basic studies. Work has thus far been done on its blood proteins, and several papers are being published on its heart and smooth-muscle pharmacology. Interestingly enough, *Strophocheilus* is the only mollusk except the mussel, *Mytilus*, whose heart is excited by neurohumors, acetylcholine, and 5-hydroxytriptamine (or serotonin). This has led to a general investigation of long-acting, blood-borne neurosecretory substances that may serve to regulate cardiac activity.

The survey work turned up another, non-cardiac structure, the penis retractor muscle, which may prove highly useful for various bio-assays. This muscle contracts when stimulated with acetylcholine and produces rhythmical contraction when treated with serotonin. Other drugs, such as bufotenine and LSD-25, also cause this muscle to produce irreversible, periodic contractions that simulate a heartbeat. This is of considerable interest in finding an answer to the old problem of whether molluscan muscles have a catch mechanism that permits them to remain contracted for long periods, without expending significant energy for such contraction.

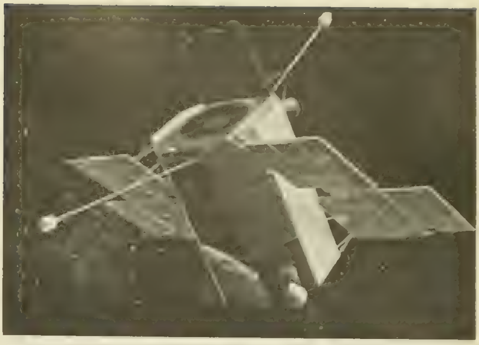
All these preliminary indications suggest that *Strophocheilus* may well prove important for South American research in the physiology of mollusks.



# SKY REPORTER

## New spacecraft are designed to carry whole observatory units

By Thomas D. Nicholson



Drawing of Orbiting Astronomical Observatory shows the antennae and star trackers erected and ready for operation.

Some time early in 1966, the United States will launch an astronomical observatory into space. A few years ago, such a plan might have seemed laughable; even today, in a time of spectacular space accomplishments, it seems far-fetched. But it is a fact nearing completion.

The Orbiting Astronomical Observatory—or OAO, as it is known—is not just another satellite. It will be a true astronomical observatory, with observatory-size and observatory-class instruments, to be placed in orbit around the earth to carry out a program of deep-space observations. The observatory itself will weigh nearly two tons and will be capable of carrying into space, and of operating remotely, telescopes up to 48 inches in diameter, 10 feet in length, and weighing a half-ton. The first satellite will not carry so large a telescope, but will be equipped with several smaller ones. At the present time, six similar spacecraft are planned, to be sent up over a period of several years; already being constructed and tested is a 36-inch telescope to be carried by the second or third OAO in the series.

The scientific mission of the OAO is identical to that of terrestrial observatories: it will observe the universe, including planets, stars, nebulae, galaxies, and the gas and dust of interstellar space. It will expand our total knowledge, rather than merely furnish us with limited information about single objects, as was done by many scientific satellites and deep-space probes launched thus far.

Space exploration has come to be closely associated with astronomy in the minds of many persons, although there are aspects that are only remotely connected—if at all—with astronomical science. It is true that in recent months some of the widely publicized accomplishments of the American space program have involved astronomical objects: Venus—with the successful fly-by of Voyager II; the moon—with the three spacecraft of the Ranger series that succeeded in sending back photographs of the moon's surface; and Mars—with the amazing accomplishment of Mariner IV in transmitting pictures of the planet to earth after seven and a half months of space flight.

Much of the effort and cost of the American space program goes into the development of a space capability that can eventually be used to accomplish many objectives; even more goes into the program of manned space flight, with a lunar excursion as the present goal. Still more research time is spent in developing and launching applications satellites—those that will contribute directly to applied research or technology in such areas as communications, weather forecasting, and navigation. There is one major branch of the National Aeronautics and Space Administration responsible for the development and execution of these programs. This is the Office of Space Science and Applications (OSSA), which at the present time receives about one-eighth of the total NASA budget.

Central portion of Orion nebula is seen in ultraviolet light. Photograph was taken with Lick Observatory telescope.

Many of OSSA's investigations involve ionosphere physics, biology, space medicine, and meteorology, and are carried out in terrestrial laboratories, computer centers, and observatories, rather than in spacecraft.

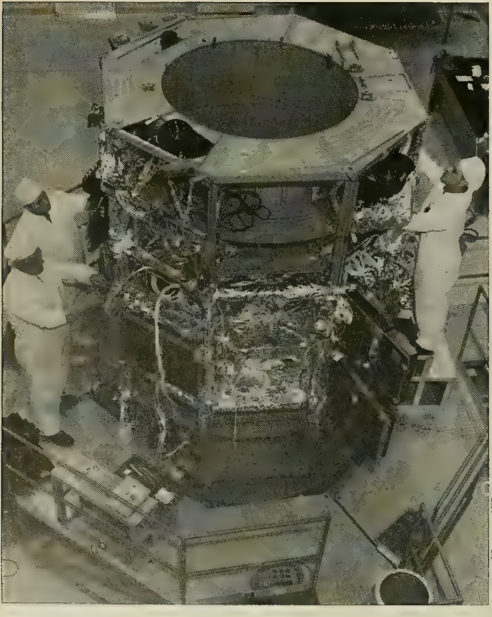
In the early years of the American space program, scientific experiments were usually incidental to the operation of the spacecraft itself. Beginning in 1959, spacecraft were designed and flown with specific, although limited, scientific objectives. Then, on March 7, 1962, the first of an entirely new class of spacecraft was launched, the first of the observatory generation. The observatory-class satellites were to be larger and would have a greater weight-carrying capability for larger and heavier experimental packages. But aside from this, satellites of the observatory generation were to be multipurpose scientific spacecraft into which a wide variety of equipment could be installed. Each of the spacecraft in any one of the groups would have the same basic structure, control system, power supply, and communications and data handling system. Each spacecraft of the same design could also be used, with only minor modifications, to carry on different experiments and combinations of experiments on successive flights.

Four designs were developed—the Orbiting Geophysical Observatory, the Orbiting Solar Observatory, the Orbiting Astronomical Observatory, and the Advanced Orbiting Solar Observatory. Several of each design, up to six in some cases, are planned, and still others can be added as new experiments are proposed. Spacecraft of the Orbiting Geophysical Observatory (OGO) design will make observations of the earth and of near-earth space from altitudes up to about 60,000 miles. The Orbiting Solar Observatories (OSO) and the Advanced Orbiting Solar Observatories

(AOSO) will be designed to observe the sun, the effect of the sun's radiation on the earth, and earth–sun relationships. The present mission of the Orbiting Astronomical Observatory (OAO) is to extend our knowledge of the origin and development of the universe. Several flights of OSO and OGO satellites have already been successful. Now it is the turn of the OAO—the largest, heaviest, most advanced, versatile, and sophisticated of the series.

It is not so much that astronomers wish to observe the universe from space, but rather that they are seeking ways to observe it without having to contend with the general atmospheric obstructions on earth. It has long been known that the air above the earth's surface places severe restrictions on astronomical observations. (For this reason observatories are constructed on plateaus and mountaintops, astronomical equipment is placed in balloons and airplanes, and high-altitude rockets are designed to carry similar instruments in their nose cones.) The atmosphere is bright with scattered sunlight by day and with moonlight and starlight at night. It causes the images of the sun, moon, and planets to appear fuzzy and the pointlike images of the stars to blur into large spots and dance about from place to place. But the most severe restriction imposed by the atmosphere is that it transmits only certain kinds of energy and is completely opaque to others. The visible energy that we call light, a small portion of ultraviolet energy, some infrared energy, and longer wave radio energy pass through the atmosphere rather freely, except for some loss through scattering. But the air is opaque to the whole short-wave region of the spectrum below the nearly visible ultraviolet, and to much of the energy that is longer in wavelength than red light.

Astronomical observatories on earth, therefore, can study celestial bodies only by observing the light, the infrared, and the radio energy that come through the atmosphere. By constructing observatories on mountaintops, the range of observable energy is broadened slightly into the ultraviolet and infrared.



**Thermal model** of OAO is in process of construction. This versatile satellite may be adapted for various purposes.

**Dr. Nicholson**, the regular author of this column, is also Chairman of the **American Museum-Hayden Planetarium.**

The Orbiting Astronomical Observatory presents the first significant opportunity for astronomers to observe, without atmospheric interference, the ultraviolet energy from various objects in the universe. The first 1966 OAO will carry two experimental packages, each designed for such observations. The experiment known as Project Celescope, developed by the Smithsonian Astrophysical Observatory, will survey the entire ultraviolet sky with four 12-inch telescopes, with the objective of making maps at various wavelengths and of identifying interesting objects that transmit ultraviolet energy. The second experiment for the first OAO, developed by scientists at the University of Wisconsin, will use three telescopes, the largest 16 inches in diameter, to study the brightness and the spectrum of ultraviolet energy coming from such specific sources as stars and nebulae. Later, as mentioned, a more detailed analysis will be made, using 36-inch telescopes.

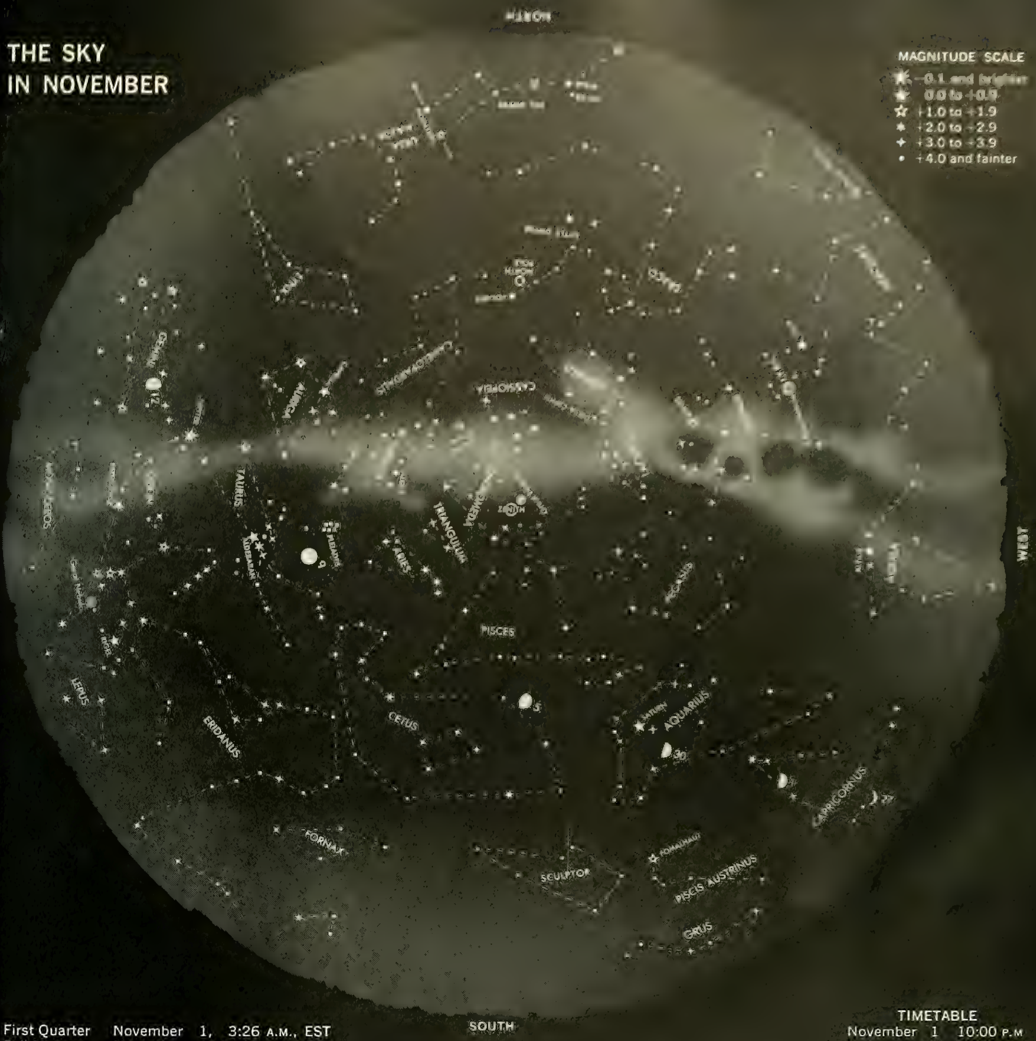
What may we expect to learn from OAO observation of the ultraviolet universe? If we could answer that question with any degree of assurance, there would be less pressing need for the OAO program. We cannot anticipate, in this case, except to speculate that findings may well be quite different from what we now know. This was certainly true of radio astronomy. Observations of radio waves coming from celestial bodies provided us with many surprises concerning both the celestial bodies and the physical laws and processes of the universe.

The little we have already seen of the ultraviolet universe seems to indicate that within the OAO program there are also surprises in store. In addition to brief observations of limited portions of the sky made from high-altitude rockets that have revealed ultraviolet nebulae (which coincide, as expected, with bright optical nebulae), discoveries have been made concerning certain hot stars that were expected to have intense ultraviolet radiation, but now seem to be surprisingly faint.

We should not expect sharp photographs of the sky, such as the one of the Orion nebula on page 28, to come from the OAO or from any of the earlier spacecraft of the series. The data will be in digitized, not photographic, form. It is planned that this coded information will be used to prepare sketches and diagrams representing newly discovered features of the ultraviolet sky. The results will probably satisfy our curiosity, but this is not the purpose.

The launching of the first Orbiting Astronomical Observatory may well go almost unannounced in much of our press. After not quite a decade of the space age, we have become accustomed to the ideas of "ordinary" accomplishments—a photograph of Mars, a rendezvous of manned spacecraft in space, or a soft landing on the moon. Compared with these, the launching of just another satellite may be largely ignored. But the OAO will be the beginning of a wholly new way to look at the universe and may be the most important astronomical achievement of the space age.

# THE SKY IN NOVEMBER



| | | |
|---|---|---|
| First Quarter | November 1, | 3:26 A.M., EST |
| Full Moon | November 8, | 11:15 P.M., EST |
| Last Quarter | November 15, | 8:54 P.M., EST |
| New Moon | November 22, | 11:10 P.M., EST |

TIMETABLE

| | |
|---|---|
| November 1 | 10:00 P.M |
| November 15 | 9:00 P.M. |
| November 30 | 8:00 P.M. |

(Local Mean Time)

November 3: In early evening, Saturn is above and to the right of the waxing gibbous moon.

November 5: The nearly full moon will interfere with viewing the weak Taurid meteor shower as it reaches maximum.

November 11-12: Soon after sunset on the 11th, Jupiter, in Gemini, rises to the left of the moon.

November 12: Mercury reaches greatest easterly elongation at 10:00 P.M., EST, but the chances of seeing it as an evening star are slight. Evening elongations in the fall are always unfavorable, this one especially so.

November 14: Saturn is stationary in right ascension and resumes direct easterly motion through the stars of Aquarius.

November 15: Venus attains greatest easterly elongation at 3:00 P.M., EST. As with Mercury, however, evening elongations of this planet are unfavorable in the fall.

November 16: The famous November meteor shower, the Leonids, which produced spectacular displays in 1833, 1866, and 1867, reaches maximum today. The hourly rate for a single observer is about 25, but the last-quarter moon will interfere with seeing any but the brightest of the meteors.

November 22: An annular solar eclipse occurs with the new moon of this date. The annulus (ring) will be visible for up to four minutes in the regions of India, the Malay Peninsula, Indonesia, and New Guinea where the shadow path of the moon is located; the date of the eclipse is November 23 in these parts of the world.

November 23: Mercury is stationary in right ascension and begins retrograde (westerly) motion.

November 24: A daytime occultation of Mercury by the moon occurs today over North and South America.

November 25-26: Mars can still be seen faintly in the evening sky this month (magnitude +1.4). It sets soon after sunset, near the slim crescent moon.

November 26-27: Venus can easily be recognized to the left of the crescent moon in the western sky, after sunset on the 26th; on the 27th it is well to the right and below the moon.

All Month: The brilliant evening star this month is Venus. Saturn, rather faint, can be seen in the southeast around sunset. Jupiter rises in the east at this time and remains visible until dawn. In the west, Mars is the evening star.

**P**elican, seen in flight, *above*, exhibits a wingspread of about six and a half feet.

# BROWN PELICAN IS VICTIM OF GULL PIRACY

In the coastal waters of Florida, piracy is a daily occurrence. The pirates are gulls, and the victim is the Brown Pelican, *Pelecanus occidentalis*.

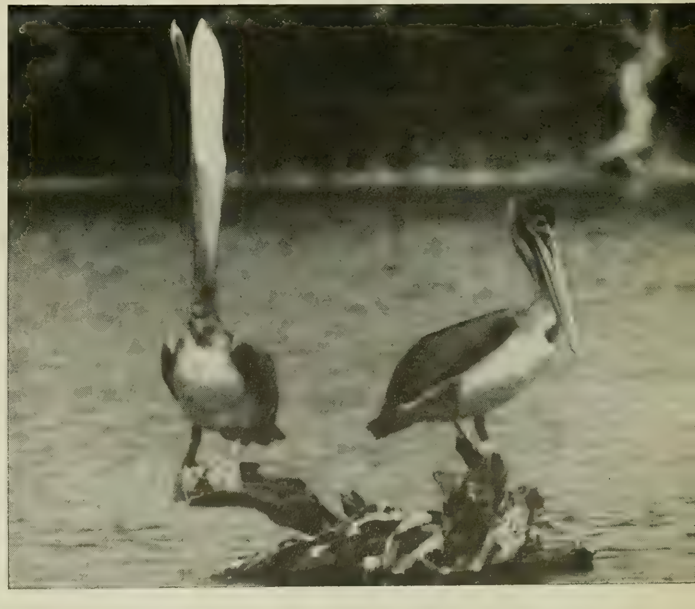
Before describing the relationship between these particular species of birds, it will be worth examining briefly some of the ways in which animal species in general interact.

Species interactions provide students of behavior, ecology, and evolution with unlimited opportunities to add to our basic knowledge in these disciplines. Such interactions may range from direct competition to full co-operation, from mere presence of two or more species at a common, temporarily abundant food source to predator–prey relationships.

More complex examples are provided by parasites: here, one species provides food and shelter for another, at times to the detriment of both host and parasite. (If, through the relationship, the host should die or become sick, the parasite would have to find another host or perish.) The tapeworm living in the gut of a dog does so by reason of its many structural, physiological, and behavioral adaptations evolved over millenniums, but other species may tap the food resources of different, usually unrelated, forms in a more or less opportunistic fashion; that is, the relationship is facultative rather than obligatory. Birds, mainly because of their conspicuousness, provide many obvious examples of such interactions.

No bird is a true parasite in the usual sense of the word—a highly specialized organism living in or on an all-providing host—but many birds take advantage of the efforts of other species in order to profit themselves. Such behavior may be as simple as stealing a neighbor's nest twig or perhaps appropriating the whole nest.

Resting before another forage, *right*, one bird stretches its neck and pouch.



### by Andrew J. and Robert Meyerriecks

Slightly more complex ways of profiting from the industry of other species are to be found in feeding interrelationships. Cattle Egrets, *Bubulcus ibis*, associate with a variety of hoofed mammals that act as unwitting "beaters" for the egrets (NATURAL HISTORY, August-September, 1960). The Cattle Egrets do, of course, gather their own food once insects have been stirred up by their herbivorous associates.

An even greater dependency on another species is demonstrated by kleptoparasites of the bird world. Frigatebirds, the leading pirates of tropical and subtropical waters, can and do

# THE GULL IS OMNIPRESENT

forage on their own, but robbery of terns, boobies, gulls, and pelicans is their usual way of getting food. Piracy is also a way of life for many gulls, and this brings us back to our opening—the interaction between two species of these pirate gulls and their victims, the Brown Pelicans.

While keeping in mind that to approach interaction from only one aspect is to see but a small part of the picture, it is interesting to consider how the behavior of the Brown Pelican—specifically its foraging behavior—fosters the relationship with the gulls.

Brown Pelicans seek food primarily in three ways; the most spectacular and best-known technique is their famous plunge from a height. When fish are sighted by the flying pelican, the bird stalls for a moment, turns, then plunges straight downward in a dramatic dive, often spiraling as it descends. Wings held partly closed and to the rear, the pelican smacks the water with a great noise and an accompanying spray, and often goes completely below the surface to seize a fish. Less spectacular, but as productive, is a second method: the pelican, from a swimming position on the surface of relatively shallow water, takes to the air, then turns and plunges from a few feet. These short take-offs and plunges are repeated until the bird has captured enough fish.

Third, Brown Pelicans resemble the North American White Pelican, *Pelecanus erythrorhynchos*, a non-diving species, in another food-seeking method used only in shallow water. Both species swim slowly on the surface, then suddenly turn their heads and great bills and plunge them into the water at a sharp angle.

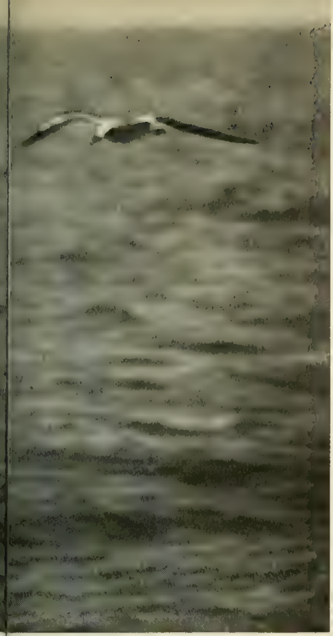
The pirate gulls—Laughing Gulls, *Larus atricilla*, and to a lesser extent Ring-billed Gulls, *Larus delawarensis*—enter the picture when the pelicans show signs of this foraging behavior. While the pelicans are resting or preening, the gulls appear to be ignoring them, but as soon as a pelican takes flight or slips from its perch into the water, the gulls are in immediate attendance. When the pelicans are swimming in shallow water and ducking their heads, the pirates swim alongside, waiting to snatch food from the pelican's pouch or bill.

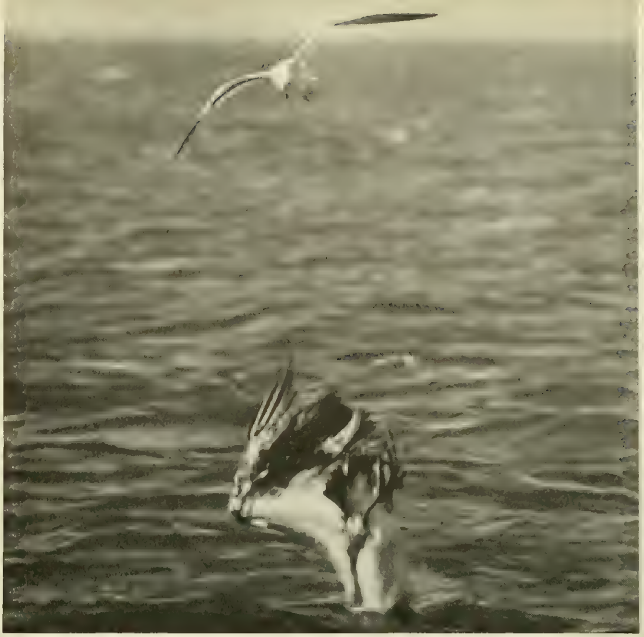
Gulls—particularly Laughing Gulls—are especially quick to gather when a line of airborne, food-seeking pelicans begins to peel off and plunge into the sea. A diving pelican attracts one or more gulls that hover over the submerging bird until it reappears on the water's surface. Then the gulls move in for an attempted theft. Typically, Laughing Gulls harass Brown Pelicans by alighting on their heads, and occasionally on their backs. From this vantage point the gull reaches over and tries to steal a fish from the pelican's pouch. If the gull does not land on the pelican's head or back, it alights on the water close to the intended victim's head, ready to grab at anything in, or sticking from, the great pouch. Sometimes a gull will try to get at a fish by putting its head completely inside the pelican's pouch, and a tug of war results.

When a pelican seizes some fish under water, it also takes in a pouch full of water, which it must remove before swallowing the prey. In order to do so, the bird must raise its head, bill, and pouch, then press the pouch against its breast in order to expel the water without losing the fish. A pelican thus engaged presents the best opportunity for the gull to strike; when the pelican has emptied its pouch of water, it merely raises its head and tosses the fish down the gullet, ending the gull's chance for success.

Once the pelican succeeds in swallowing its fish, the gull normally departs to search for another potential victim, but sometimes a single gull or a small flock will remain in attendance on the same pelican. At times, flocks of gulls will harass one pelican for long periods, but the latter never seems disturbed by the wheeling, screaming, snatching mob. At no time have I ever seen a pelican threaten or attack a gull, even though the pirates were most persistent and managed to rob the pelican regularly. Even when a gull alights on its head, the pelican makes no effort to rid itself of the would-be thief.

Laughing and Ring-billed Gulls rob a number of other species in Florida waters—terns, white ibises, various shore birds, and others—but it would seem that the consistent, easily recognizable, food-seeking behavior of the Brown Pelican virtually serves as a "signal" for the always watchful gulls.



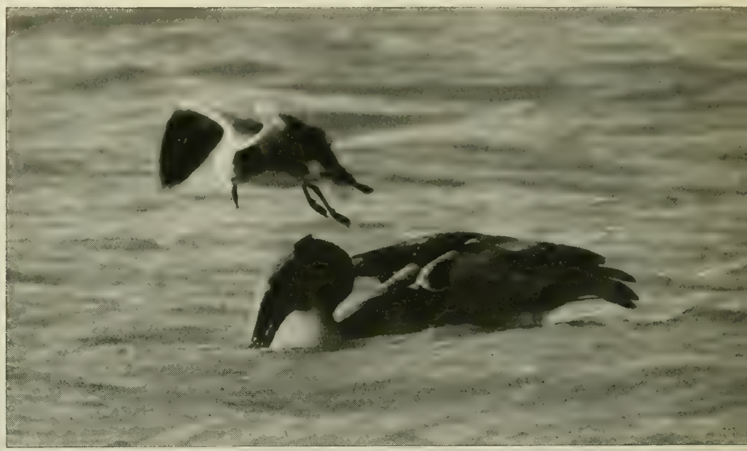


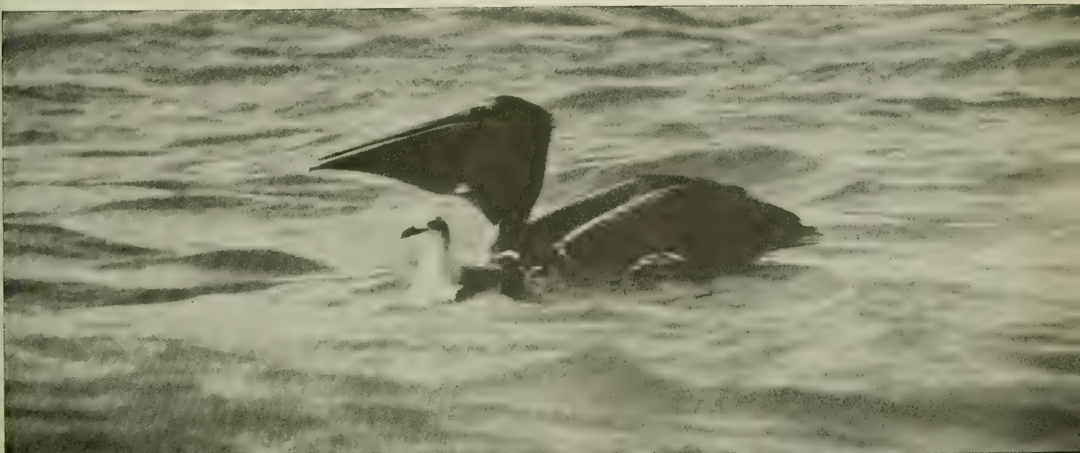
Photographs on these pages show how the Laughing Gull accompanies a Brown Pelican on its food quest. *Above left,* the gull flies toward the diving pelican.

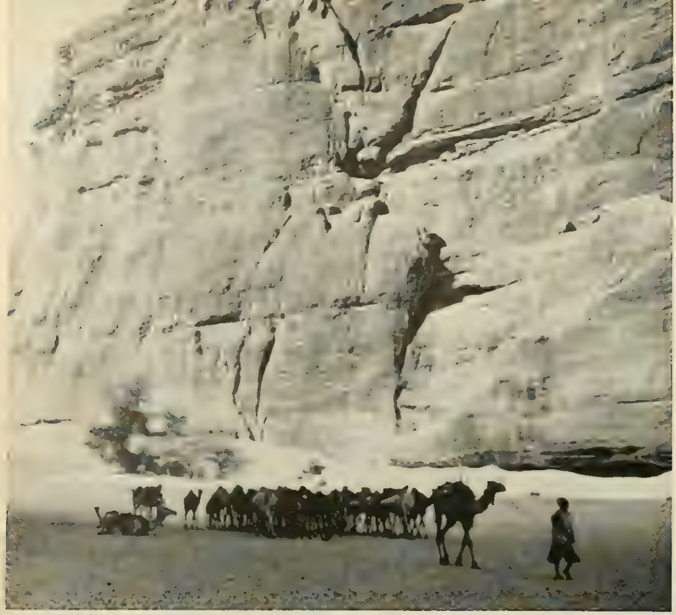
As the pelican, *above right,* plunges beneath surface, gull hovers, waiting for it to emerge. Note how the pelican draws feet close to body as it dives.

Gull, *right,* closely pursues pelican. To swallow catch, pelican must first expel water in its pouch; during this moment, gull attempts to snatch fish.

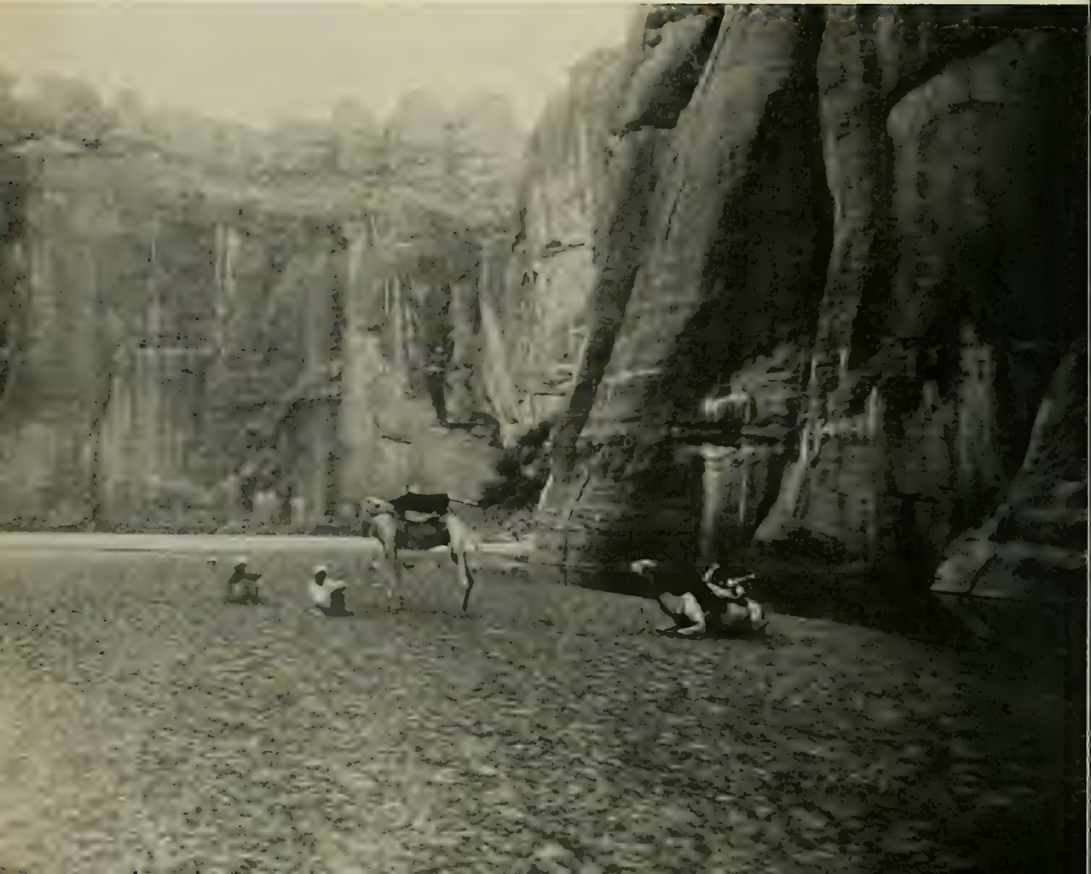
Once the pelican, *below,* closes bill and swallows fish, gull's opportunity is lost. Gull drops to water, drifts, and waits for the pelican's next dive.







**Camels** pass between walls of Archei in the Ennedi region of Africa's Sahara.



**Each band**, regardless of its size, seems to have prearranged place by the pool.

# Guelta

## Source of water is mystery in the Tchad

By W. Gurnee Dyer

Although unmarked on most maps of Africa, the guelta of Archei lies in the southern Sahara. The evening before we left Abéché on our way northward to Fada it was suggested that we visit this part of the Tchad's Ennedi region. It is a remote land whose peoples are endlessly concerned with a search for water.

It was early in March, and after many delays, that we finally cut

# of the Bleak Sahara

through the military red tape of the French command stationed in the old *Beau Geste* fort, found two guides, and set out for this part of the Tchad.

We wound steeply up and down, through narrow defiles, over flat tables of rock and rough steps carved by the elements in the sandstone. After many hours under a searing midday sun the panorama changed to a trackless plain, unbroken except for the sight of occasional nomads. Finally, in the growing darkness, we made camp, watched by herds of small dorcas gazelles.

An early start is a must in desert areas; the night-cooled sand is packed tight but quickly becomes powdery under the hot sun. Six in the morning found us again on our way.

We inched along on level, sandy terrain, threading our way between drinn bushes and siwak trees that reminded us of our own cottonwoods. We eventually emerged onto a gravel floor, walled by enormous rock formations jutting skyward.

From here we had to guide our desert-equipped vehicle between thousands of stony mounds, six to eight feet wide and a few feet high. These were the burial places of the long-dead inhabitants of the country. This scene soon changed to vast, undulating plains, crisscrossed by numberless wadies shimmering in the Sahara's heat.

Suddenly the rocky mass of Archei loomed against the distant horizon. We slowly approached the steep, red cliffs and the white sand clearing between them, dotted with siwak trees.

In Archei's wadi and in the guelta itself, towering sandstone masses rise hundreds of feet on either side and, where the canyon narrows to fifteen yards or less, these massive walls seem to meet. Where you can see the summit, great spires are carved and molded into fantastic shapes. Eagles screamed as they wheeled and soared above. A bedlam of chatters, squeals, and barks came from excited baboons in the rocky ledges overhead. As we rounded a bend in the canyon's path, we saw before us the first of Archei's water holes. Nestling in the sandy floor against the lofty wall, it looked to our Western eyes much like an oversized plate of black bean soup.

In the little group we first joined were ten or twelve nomad men, four or five women, and a few small boys and girls. They were a friendly and happy lot, carefully tending their flocks and herds, drinking, washing, and gossiping as they worked.

Clustered about the pool's edge was a varied collection of camels, sheep, goats, donkeys, horses, and cattle, carefully watched by perhaps fifteen or twenty nomads who allowed them just enough time to drink their fill, then chased them off to make room for the waiting and thirsty ones. In the pool stood a cross section of all this desert life—up to their knees or bellies in the inky black liquid—drinking and soaking themselves.

Some of the nomads had dug holes three or four feet deep and wide enough for a man to sit in. Here they washed themselves and their clothing, drew water for cooking and eating, and enjoyed the luxury of a water supply coming from the pool but filtered through the sand that separated it from the original source.

We later examined many of these man-made borings and found the water shades lighter than in the main pools and, certainly, free of nearly all the dirt and matter floating about in the water of the guelta itself. Several members of the famed desert camel patrol, whom we had met several days before, had warned us not to walk or wash in Archei's pools, as there is great danger of contracting bilharziasis, the dread disease endemic in most tropical countries. (North of Fada, as we rode camels into Ennedi's hills, we found gueltas, such as Ourii, but with deeper pools set in solid rock. In these regions no filtering sand holes can be dug and, to add even more ingredients to the water, myriads of tiny desert birds fly about, depositing marble-like droppings.)

Unfailingly, at break of day a low, deep rumble like distant thunder announced the approach of hundreds of camels. They came in groups, herded by fierce-looking men armed with daggers, knives, swords, and spears. These were the camel herders, guardians of the most valued of all desert animals. Evidence of great wealth, the camels belonged, not to the herdsmen, but to tribal chiefs of the Gorane or Bideyat people. Each group, whether large or small, seemed to have its prearranged place at one of Archei's water holes.

Groups of camels came and went all through the day, but the great herds apparently remained a long time, finding shelter from the desert's blistering heat. Only camels were allowed to penetrate deep into the canyon's inner reaches or to drink at its larger pools far inside the guelta. Horses, cattle, and other animals were never permitted beyond the entrance or watered at any but the outer pool.

During the hottest part of the day, life slowed to a stop. No one did anything that was not absolutely vital until the sun began to sink below the silhouetted rim of Archei. Then, from within its depths, the evening exodus began as animals moved into the darkening desert to feed on siwak trees and desert grass. As the activity increased, every inch of Archei's cavernous floor seemed filled, its thick walls appeared to bulge, its length and breadth shook and quivered with the roar that came from the throats of grumbling, humpbacked camels, pressed close together as they slowly shuffled by. Imperceptibly at first, the moving mass began to thin, and once more peace and stillness fell on Archei.

Each night some ten or twelve men remained. They were Archei's janitors, serving their tour of duty. This "housekeeping" is rotated among all the nomads of the region. The silent, white-robed figures swept dung from each pool's surface with great palm fronds, dug new holes in the sand, and filled old ones. When all was done to their satisfaction, they formed groups around fires and, sitting cross-legged, warmed their evening meal of gruel-like millet, camel's milk, tea, dates, dried meat, and sometimes honey. We often joined them, sitting on skins or brightly colored blankets, while two or three camels, hobbled for the night, stood behind us, sleepily watching the group with half-open eyes.

**Only** camels are allowed to penetrate into the inner reaches of the guelta.

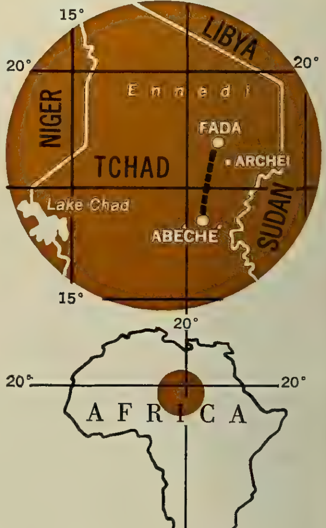
As darkness deepened, the final hour of prayer was called. Facing east to Mecca, the guardians of Archei prostrated themselves and worshiped for the last time until dawn. Then, rolled in their heavy, woolly blankets against the desert's chilling night, they fell asleep under the starlit sky.

Archei's routine goes on, repeated endlessly without change. Archei is a lonely island in a sea of sand; a refuge from the desert's heat where life can still go on because there is water.

Where does this seemingly inexhaustible supply of water come from? What is the history of this extraordinary spot? Did its pools ever go dry? Here the word "guelta" has come to mean a spot where there is a slow seepage of ground water. In this part of the Ennedi the seepage is probably through fissures of granitic rock, sandstone, or unconsolidated material. The movement of the water at Albuquerque, New Mexico, is possibly similar; when the Rio Grande is low, the plants, such as cottonwoods, absorb all available water during the day, with a resultant drop in water level. With much less transpiration at night, there is a higher level each morning; during the day the level drops again. Similarly, the herds drink the water of the guelta of Archei until it seems virtually gone, but at night the seepage replenishes the pool.

The guelta of Archei has never gone dry within the remembered history of the nomads. It seldom rains there—sometimes only once or twice a year; therefore, rain alone is of little help in replenishing the guelta's pools. During the day, Archei's water is sucked into throats and bellies of as many as two thousand animals, and its supply shrinks. The amount of water taken in a single day is enormous. Horses, donkeys, cattle, sheep, and goats must drink at least once during the daylight hours; they cannot go without water longer. Camels come every fourth or fifth day if they belong nearby, and each swallows perhaps a hundred liters a visit. It is considered dangerous for camels to go without water for periods longer than a week.

Archei and all the land around it was once green and fertile. Vegetation was lush, and rivers flowed in the now-dry wadies. Game of all kinds abounded. Man, too, lived, hunted, cultivated crops, and learned how to create the paintings still vividly decorating so many of the Tchad's caves, including those at Archei. The paint-



**Map** shows Ennedi region, and marks route from Abéché to Fada in the north.

**Large herds** of camels all belong to the Gorane or Bideyat tribal chieftains.

ings tell us much about life and times before the Sahara spread its killing sand over almost the entire region. The desert moves south about one hundred and fifty feet each year. As the sandy wastes have grown more and more arid, little of the desert game has survived. Lions, giraffes, elephants, and the like, have long since left. Only in the cave paintings will one see them as they once lived. Today, in addition to a few hyenas and baboons, there is one other relic of the green and fertile days still living in Archei. There are crocodiles in the murky waters.

It was on our second afternoon deep within the guelta's walls that two tall nomads in white turbans told us that the crocodiles come out at the far end of the pool when all other animals have gone. Suddenly, and after what seemed hours of waiting, there crawled from the farthest pool and headed for the only remaining patch of sunlight, not one or two, but four crocodiles. Frantically we snapped pictures, not daring to take time out for a good look at the subjects for fear that they would disappear. We had been told not to expect to find the crocodiles of Archei as big as those seen in the Nile. But the ones in the guelta were not small by any standard, measuring well over six feet. They seemed to be lighter and greener in color than those of Uganda, and they could boast as fine a set of teeth.

The crocodiles come out late each day when all is quiet, and no one knows where they go to hide. It is thought that there must be underground caves not visible above or through the waters of the guelta. They live on camel droppings and on fish, of which there are many here, some as large as a meter long. The crocodiles are regarded as a boon, because they help keep the pools clean.

It is doubtful if all of the caves at Archei have been explored. Some are huge, some tiny; there are deep and shallow caves and high- and low-domed ones. They are sometimes level with the guelta's floor; sometimes they are far above, and can be entered only after a steep climb.

Caves such as these are found scattered throughout Ennedi. Long ago they served as shelters for those who lived here. Walls and ceilings of almost all we saw bore evidence of life in times when this was a land of green and tropical forests, flowing rivers, and abundant game. These caves are not only of great interest because of artifacts, bones, and other relics found in them; they are well known for their rupestrian engravings and paintings.

There does not seem to be agreement among scientists on the exact date of this primitive art, but it is generally thought that the decorations cover thousands of years of effort by hundreds of artists. The earliest of Ennedi's paintings are said by several sources to date before the year 3000 B.C. Men with round, shaven heads are depicted in yellow, red, and black; they carry bows, arrows, and clubs, and hunt wild game of that era. Elephants, rhinos, giraffes, cheetahs, and leopards are all recognizable.

We left Archei in late March, just as the desert winds began—a sandblasting by nature of animals and terrain. Although the explanations of geologists are without doubt a matter of undeviating fact, the guelta of Archei remains a place of deep mystery and colorful timelessness to all of those who find their way to it in the vast, northern Ennedi region of the Tchad.

### EMIGRATION PATTERNS ARE COMPLEX

# Dorylines: Raiding and in Bivouac

## PART II

**By T. C. Schneirla**

**Excited workers** in the nomadic phase move in circles in a laboratory nest.

Part I of this discussion of legionary ants (Natural History, October, 1965) focused on raiding operations, in which *Aenictus* reveals its doryline relationship in such primary operations as forming branched chemical trails and attacking prey. It is clear that the behavior of *Aenictus* is complex, although primitive and simple in comparison with that of *Eciton*. This point is illustrated further in the emigrations, which in *Aenictus* arise more directly from raiding than in *Eciton*.

As an *Aenictus* raid continues, two important changes are likely to follow sooner or later after much booty has been returned to the rear: caches are formed and a new outpouring of traffic may begin. Caches are booty dumps that usually are formed near the main trail branches where raiders drop their loads and rush back into combat, or where others release their loads after having been blocked in traffic. The second change, a new outpouring of workers upon the trail, results from a long caravan of booty carriers entering the bivouac.

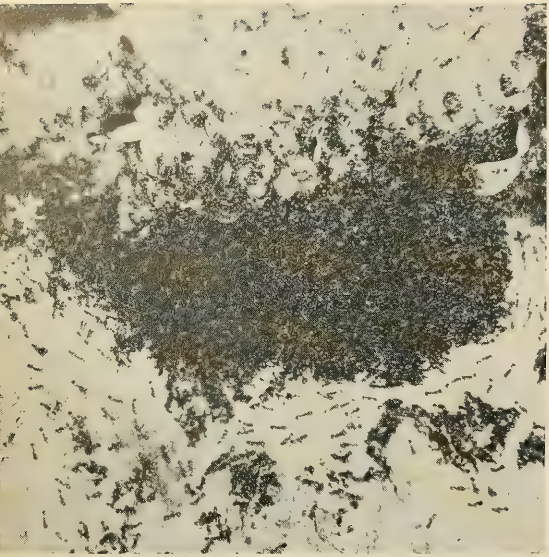
The prompt result may be an emigration—that is, a complete movement of the colony, with its entire worker personnel, its queen, its transported brood, and accumulated booty—to a new site reached by following the chemical trails of raiding. Early in the nomadic phase, however, with the presence of many callow workers that become agitatedly active when food is gone, the new exodus leads more often to an extension of raiding than to an emigration. When an emigration then occurs, the workers bearing packets of tiny larvae usually do not appear from the bivouac until some time after the exodus has begun. But later on in the phase, when the larvae are larger, more widely distributed through the bivouac cluster, and a potent excitant to workers, their actions—and, quite probably, their increased odorous effects when unfed—have the evident result of causing workers to grasp them and carry them forth promptly.

**Queen**, *arrow*, covered by worker ants, passes in an emigrating *Eciton* column.

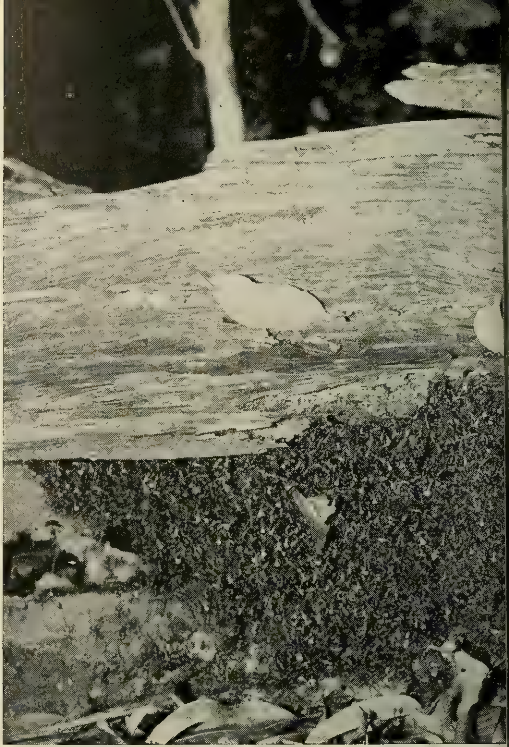
Brood carrying from the bivouac may begin soon after the main traffic reversal is under way, if chiefly unladen workers return from the raiding front, but is slower if the return of booty has been greater. Once brood carrying from the bivouac begins, however, it continues (barring interruptions, as by heavy rain) until the entire colony has moved. At the height of the movement the column often exceeds a half inch in width, appreciably thinning ahead of traffic blocks caused by groups of workers struggling along with oversized pieces of booty.

Another and more predictable cause of column thinning during emigration is the passage of the queen. She moves along steadily under her own power, but somewhat more slowly than the general stream of workers (which runs at the rate of about one yard in twenty-two seconds); also, she is slowed by the workers that surge in masses around, over, before, and after her. One used to seeing the sizable queens of *Eciton* in their emigration runs is unprepared for seeing one of the relatively diminutive *Aenictus* queens running the route. Still, these queens, both the large *Eciton* and small *Aenictus*, are highly attractive to the workers, which form similar long entourages about them in the emigration. The entourage of the *Aenictus* queen is usually a yard or two long, in comparison with the several yards usual for *Eciton*. In both cases, the queen has a group of unladen workers before and after her in the column. These are a kind of royal guard that is regularly clustered around her in the bivouac—evidently older workers strongly odor-affiliated to the queen. In *Eciton*, older workers compose both the entourage of emigration and the queen's cluster in the bivouac. This is clear from their darker appearance, as age brings with it an increased pigmentary darkening.

The prompt transformation of raiding into an emigration seems to be a distinct *Aenictus* characteristic that we



**Bivouac,** *above,* of a colony of *Aenictus laeviceps* forms beneath a rock. The emigration column enters below center.



**Colony** of *Eciton hamatum* is agitated, *right,* as queen and her entourage, on log, leave during a nocturnal emigration.

may consider primitive, in contrast to the far slower and more complex transformations typical of the *Eciton-Neivamyrmex,* or E-N, group. As the *Aenictus* larval brood grows and its stimulative potency increases, emigrations occur more frequently, until the daily total may be three or four. This impressive power of the brood to arouse, maintain, and increase colony nomadism offers excellent evidence for W. N. Wheeler's concept of "trophallaxis" (food exchange). However, our evidence warrants substituting the term "reciprocal stimulation," which more adequately conveys the broader meaning of a complex, bilateral process of varied tactual and chemical effects (including nutritive and neurosecretory effects) between workers and brood, with the queen also involved.

Emigrations early in the nomadic phase, in the absence of interruptions, usually run their course quickly in *Aenictus,* with the entire colony of about 100,000 workers, as well as brood and queen, moved to the new bivouac site within little more than two hours. This interval is considerably shorter than in *Eciton,* because of the smaller size of the workers and the smaller colony populations. *Eciton* emigrations at a comparable time in the phase take a minimum of five to six hours in *E. hamatum,* and much longer in *E. burchelli.* As the illustration on page 47 of Part I showed, the workers of *Aenictus* are much smaller than those of *Eciton.* In addition, their colony and brood populations are correspondingly smaller than other dorylines in the E-N-A genera and in *Anomma.* Many important differences in colony function and behavior seem related to these differences.

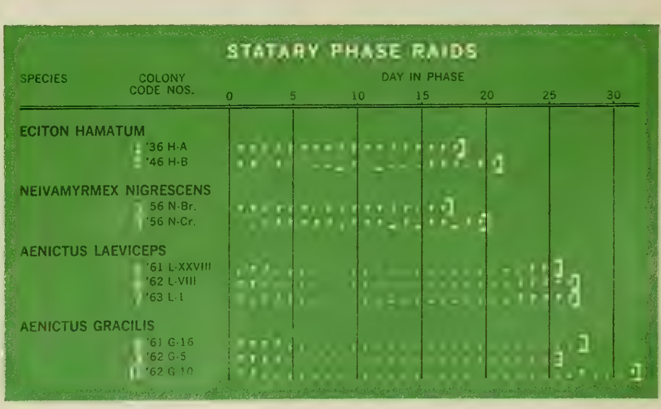
As the *Aenictus* nomadic phase progresses, interesting changes appear. First the emigrations take an increasing time to run their course. The larvae are now larger and must be carried by individual workers. They are held head-end forward and slung back under the worker's body in a characteristic ponerine manner. In late nomadic days, once the larva-carrying column is well under way, it is likely to overrun the zone of raiding into new terrain, so that treks of as much as eighty to one hundred yards may occur. Some of our records suggest that, in so doing, the colony hits upon and follows a chemical trail developed earlier by another colony of the species. Relatively great distances are thereby covered, incidentally insuring new, unworked terrain for the successive raids. In twenty-six emigrations carried out by a colony of *A. laeviceps* in one nomadic phase of eighteen days, a total ant-trail distance of more than two-thirds of a mile was covered.

Causes of the shift from raiding to emigration, although still unclear, evidently center upon stimulative relationships between workers and the larvae they feed. Laboratory observations suggest that the workers are attracted increasingly to individual larvae as their size and stimulative potency increase, and that one of two reactions may occur: workers drop food upon active larvae or pick up vigorously wriggling larvae and carry them off. Observational results suggest that the latter reaction occurs with increasing frequency as the food supply runs low. Behavioral changes seem to sweep quickly through the simple *Aenictus* bivouac cluster, however, and once the workers on one side of the mass are well started in carrying out the larvae, the procedure probably causes others to follow suit.

There are also interesting differences

in the ways in which raids and emigrations begin as the nomadic phase extends in *Aenictus*. As the typical eighteen-day phase advances, emigration steadily becomes less predictable as an event following the exodus stage of raiding. Often two or more reversals of traffic may occur, each followed by an exodus that extends raiding, before an outpouring with brood marks the start of an emigration. Another new feature is that the exodus with brood may begin rather suddenly, either after an interval in which booty-laden returns to the bivouac are scanty or after an interval of (external) quiescence following the return of all raiders to the bivouac. "Quiescence" does not mean that the colony is dormant, as indications are that actions centered on brood feeding continue within the cluster. If we view an *Aenictus* emigration as the result of the mass excitation of workers to feeding relations with the brood, we can better understand that the threshold of emigration in their colonies can be reached more directly through uniform intrabivouac behavior and simpler relations with the raiding operations than can be found in the *Eciton-Neivamyrmex* group.

In *Eciton*, emigration is a complex event that has several prerequisite stages in the development of a day-long sequence of raiding operations synchronized with the march of environmental events between dawn and dusk. In *Neivamyrmex nigrescens* it is a complex process that occurs as part of routine nightly events arising from a raid begun at dusk. In the simpler activity sphere of *Aenictus*, both raiding and emigration are far less related to events in the day-night cycle, far more directly centered upon events within the colony. Thus, they often appear to occur by chance. The role assigned to chance in predicting these results, however, may be expected to decrease as mass behavioral processes and their underlying conditions within the colony become better known.



RAIDING FREQUENCY in the statary phase is different for three genera. *Eciton* and *Neivamyrmex* both show decrease, while *Aenictus* ceases surface raiding.

The more prompt and more direct occurrence of emigration in *Aenictus* seems attributable not only to simpler raiding operations but also to more direct and uniform processes of communication between worker and brood populations in the bivouacs. Although this hypothesis rests upon scattered evidence, the brood-stimulative theory from which it derives is a strong one. One fact of significance for the entire process of cyclic colony behavior is that the brood and worker populations of *Aenictus* are quasi-monomorphic, that is, they are composed of similar individuals that react in much the same manner under the same conditions. This, together with the relatively small colonies, means that a wave of excitation (due to increased actions of larvae, perhaps also to secretions released by larvae in the unfed condition) can spread far more quickly across the shallow platter-shaped *Aenictus* bivouacs than across the more complexly organized, internally diversified bivouacs of the E-N group. In the simpler *Aenictus* bivouac situation, once the reaction of suddenly grasping larvae and moving out is under way in one place, other workers respond quickly to the exit cues. The speedy transformation of *Aenictus* raiding to emigration seems explicable on the basis of relatively simple group behavioral relations.

But in the heterogeneous, large populations of E-N colonies, the complexity of raiding operations opposes quick reversals of colony behavior, and in the bivouacs, subgroups engaged in differing behavioral operations are inevitably present, most of them resisting the stimuli to radical behavioral changes (such as that of grasping larvae and moving off) until raiding is far advanced. With *Eciton,* I have been able to force premature emigrations only by means of widespread, intensive stimulations of bivouac surfaces, as by using a mirror to direct the hot, bright rays of a sun-fleck against the mass for several minutes.

IN the complex daytime situation of a nomadic *Eciton* colony, extensive excitations of workers (through the return of a long procession of booty carriers) can lead to waves of exodus from the bivouac. These waves are generally absorbed in the expansion of the great raiding systems until darkness terminates the raids and promotes such uniform behavior as stereotyped trail following. In the advanced evolutionary status of *Eciton,* the more complex behavioral relationships between brood and workers basic to raiding and emigration have become synchronized with the regular day-night sequence of external events. In *Aenictus,* which has retained the primitive condition of smaller, more uniform colony populations, these patterns of mass behavior are controlled essentially within the colony, so they are simpler and operate much more freely in time. Even so, *Aenictus* belongs with the E-N groups in its cyclic functions.

In all three genera, the nomadic phase is governed by the duration of the main sweep of development in which the brood stimulates the adult population intensively—about eighteen days in *A. laeviceps* and *A. gracilis,* nineteen days in *N. nigrescens,* and sixteen to eighteen days in *E. hamatum.* In all three, the maintenance of a high level of nomadic function depends similarly upon summated stimulative events from the brood, and not a hypothetical "need for food." When the level of brood excitation falls sharply with larval maturation, as in *Eciton,* and with postlarval growth changes, as in *Neivamyrmex* and *Aenictus,* the colony lapses into the statary condition.

Because *Aenictus* has a nomadic-statary cycle equivalent to that of *Eciton* and *Neivamyrmex,* these three form an E-N-A group of genera in the dorylines in which colony functional phases change regularly and according to stimulative changes depending upon the brood. The most striking similarity between the archaic *Aenictus* and the far more specialized E-N genera is the duration of nomadic phases. Certainly the most striking difference is in the duration of the statary phase, which is about twenty-eight days in both *A. laeviceps* and *A. gracilis* in contrast to twenty or twenty-one days in the *Eciton* species studied and eighteen or nineteen days in *N. nigrescens.*

This statary-phase difference is sur-

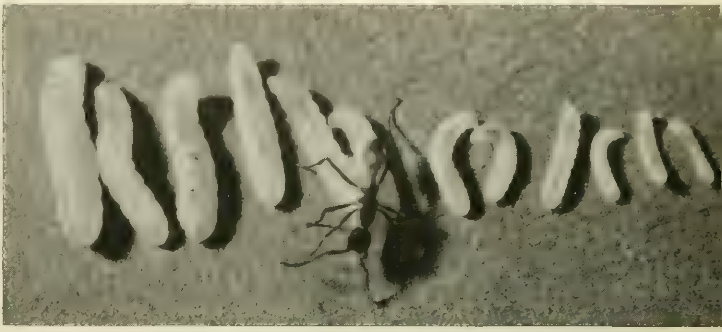
MONOMORPHIC BROOD of mature worker larvae has just been removed from an

**_Aenictus laeviceps_ bivouac. Colony had been in early stages of the statary phase.**

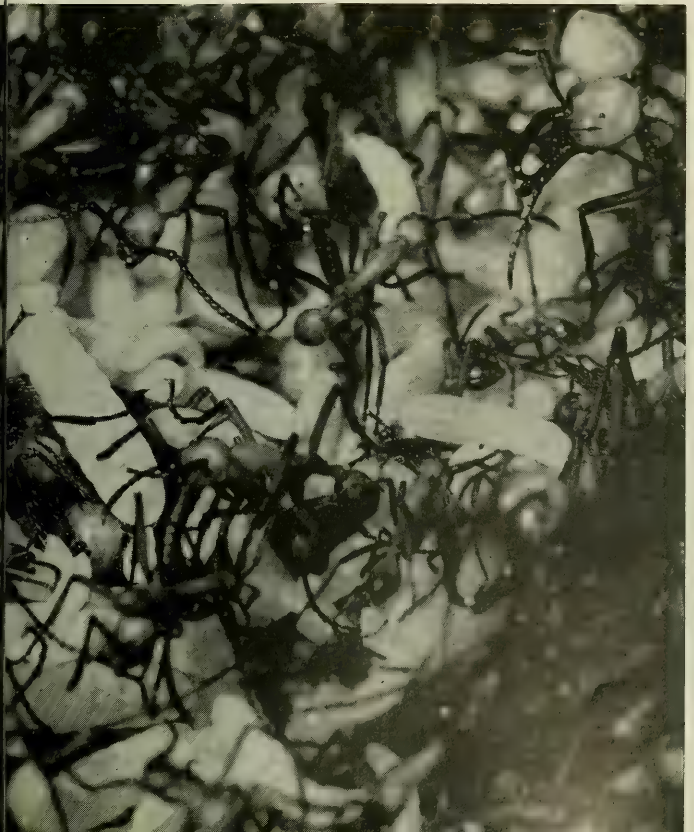
prising, for in all three genera the principal cause of the statary phase is the onset of the pupal stage in a maturing brood. The crucial point, however, is how this phase ends, an event that in *Eciton* and *Neivamyrmex* depends specifically upon the emergence of the brood as callow workers. But in *Aenictus* the statary phase cannot end for this reason, as the pupal brood has matured in the first three weeks of the statary phase. The brood then merges into the general worker population during the days remaining before nomadism begins.

This difference requires us to compare functional events in the three genera during the statary phase. In all three, the phase begins in much the same way: first the larval brood matures; then the queen becomes gravid and delivers a new batch of eggs in a single series. In all three genera, the delivery of eggs begins at about the end of the first statary week and ends within eight to ten days (around statary-day 16). In all three, the queen seems to function similarly during this event: that is, in maturing and delivering the new batch of eggs she responds to changes in the colony situation centered on an abrupt shift in its stimulative and nutritive conditions enforced through brood changes at the end of the preceding nomadic phase. All circumstances indicate that as the larvae mature and cease feeding they continue for a time to excite the colony at a high level, accounting for a wave of grooming and feeding the queen by workers, which soon brings her into the gravid condition.

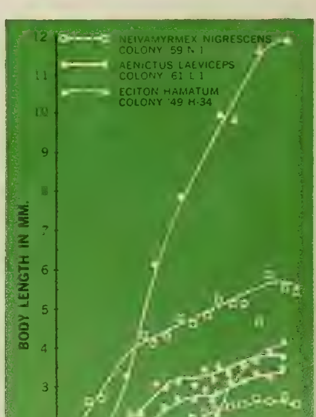
The differences seem to center on how the new brood begins its development in each of the three genera. Let us start with the E-N broods, from which polymorphic workers develop. The causes of polymorphism, certainly complex, seem attributable in these ants to certain advantages of the first-



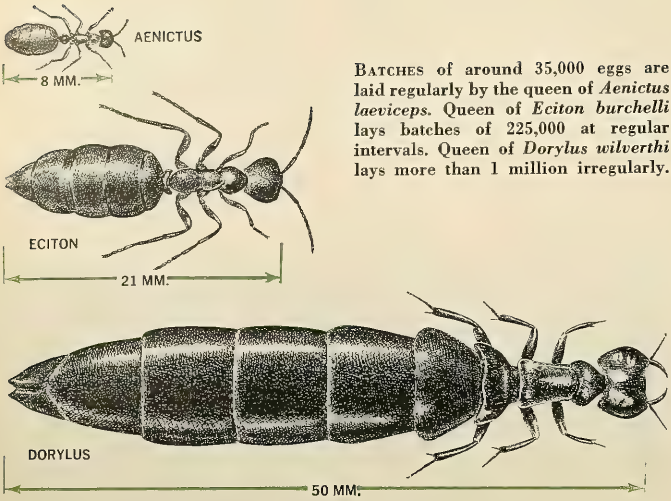
**Large larvae** of *Eciton hamatum* will be major workers; small will be minim.



**Workers,** *left*, from a newly statary *Eciton* colony, are busy with larvae.



**Growth rates** and size ranges differ for larvae of three doryline genera. Upper curves depict a brood's largest members; lower curves depict smallest.


AENICTUS
8 MM.
ECITON
21 MM.
DORYLUS
50 MM.

**Batches** of around 35,000 eggs are laid regularly by the queen of *Aenictus laeviceps*. Queen of *Eciton burchelli* lays batches of 225,000 at regular intervals. Queen of *Dorylus wilverthi* lays more than 1 million irregularly.

laid eggs that result in developmental superiorities over those next in the series, these over the next ones, and so on. It is quite possible that the advantages of the first-laid eggs begin before they are laid, in their losing the least through ovisorption (absorption of nutriment) as they pass down the ovarioles of the queen as oöcytes. Accordingly, they are the first to become embryos, then the first to become microlarvae and to feed. Thus they gain advantages over the others in social stimulation and in feeding—advantages they maintain throughout the larval and pupal stages of development. The result is that individuals developing from first-laid eggs become major workers, whereas individuals produced later in the series become intermediate, minor and minim workers respectively.

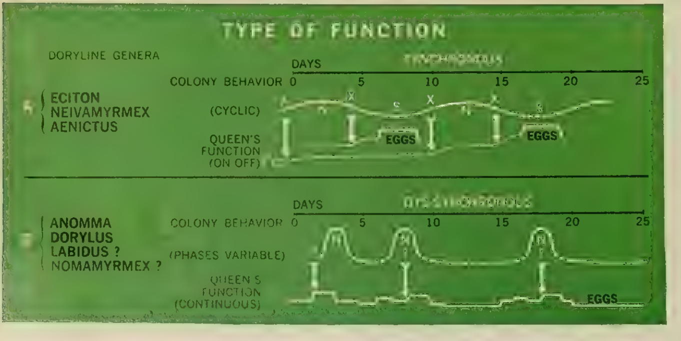
*Aenictus* resembles *Eciton* and *Neivamyrmex* closely in the schedule of egg delivery, but it differs radically in the developmental circumstances in its colonies that finally produce monomorphic, rather than polymorphic, broods. First, the queen, although she is relatively small, delivers a relatively large batch of eggs on a schedule close to that of E-N; second, the workers pass through the statary phase not just underactive and on a reduced level physiologically (as do those of E-N colonies), but so near a condition of dormancy that after the first four or five days of the phase they remain in their underground bivouac without engaging in any surface raiding at all.

These circumstances seem to result in effects on the brood and colony that may account both for the longer statary phases of *Aenictus* and for the way *Aenictus* colonies end this phase. Three hypotheses may be offered regarding the factors that affect the new brood in its earliest stages: (1) the oöcytes are all reduced so radically in their nutritive contents through extreme ovisorption in the queen that they start at much the same low physiological level; (2) at this low ebb, the eggs offer far less attraction to the workers than in *Eciton* and *Neivamyrmex*, so there is far less handling and licking of the eggs by workers—an activity that promotes a differential early development in the egg series in the E-N; and (3) the workers are unresponsive to the eggs by virtue of their own low physiological condition. (Significantly, the eggs in species of archaic ponerine genera, such as the Australian bulldog ant *Myrmecia*, are in a dry condition after laying and are passed over by workers until they enter the early larval stage.)

As a result, all the eggs of a new *Aenictus* brood begin and pass through their development in nearly the same condition and at the same pace. It is interesting to speculate as to what secretions (of queen, workers, and brood) in E-N colonies may be deficient or even lacking in *Aenictus*.

It is clear that radical differences in function exist between *Aenictus* and E-N. Even the maturation of the pupal brood after about three weeks in the statary phase, an event that promptly stirs E-N colonies into nomadism, seems to be only a partial excitant to *Aenictus*, which at that period begins to raid weakly without any signs of emigrating. *Aenictus* colonies become nomadic only when the new brood has reached the early larval condition and is feeding. Thus, for them, the essential to set off nomadism seems to be the ending of a preliminary pupal-maturation excitatory effect and a subsequent excitatory effect centered upon the minim larvae.

Despite these differences, similarities in the timing and general properties of factors essential to the E-N-A types of nomadic-statary cycles suggest a common evolutionary origin. It would seem, on the other hand, that their hypothetical common ancestors

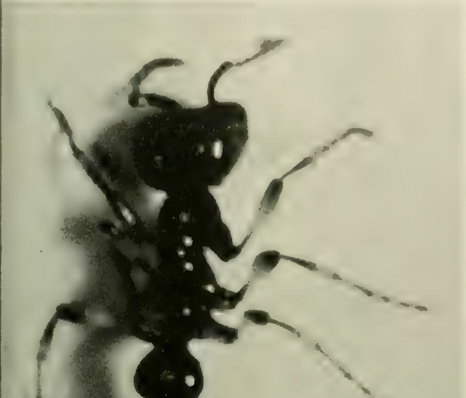


**Regular** cyclic functions of Group A are based on synchronous reproduction processes; varying functions of B are based on dys-synchronous reproduction.

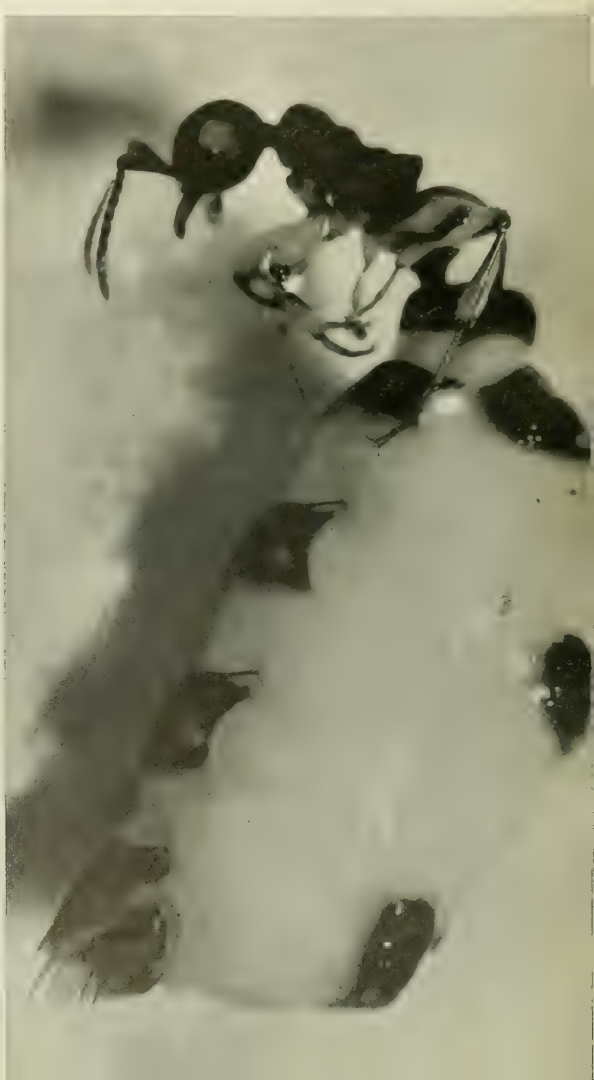
must have diverged early from the ponerine-like stock from which arose *Anomma, Labidus,* and other dorylines of great colony populations that exhibit isolated nomadic episodes of markedly irregular timing. The probably archaic conditions of smaller colonies and monomorphic population seem to have succeeded well enough in *Aenictus* to have been retained through its evolution in the Old World.

Ancient conditions in the New World, however, presumably offered the primitive dorylines a greater variety of habitats in the forested and other terrain invaded by them than existed in the Old World. Far more extensive adaptive radiations may have arisen, advancing them much further into specializations than in the *Aenictus*-like stock remaining in the Old World, although the evolution of both continued to center on the nomadic-statary cycle. Consequently, in *Eciton* and *Neivamyrmex,* under the resulting conditions of greater selective pressures, a far greater diversity in species structure, function, and behavior arose than in *Aenictus.* We therefore find closely related species of *Eciton,* as for example *E. hamatum* and *E. burchelli,* strikingly different in these respects, whereas closely related species of *Aenictus,* as for example *A. laeviceps* and *A. gracilis,* are strikingly similar.

This preliminary comparison of existing doryline ants points to the coexistence — in this subfamily — of genera with large colonies that exhibit quasi-cyclic, irregular nomadism and other genera with smaller colonies that exhibit cyclic, regular patterns of nomadic behavior. As an exercise in insect social behavior, it also indicates a high degree of plasticity in factors basic to the evolution of the latter—the E-N-A type of cyclic behavior—from which there rose the highly specialized patterns that are characteristic of *Eciton,* as well as the primitive *Aenictus* system of predatism and nomadism.



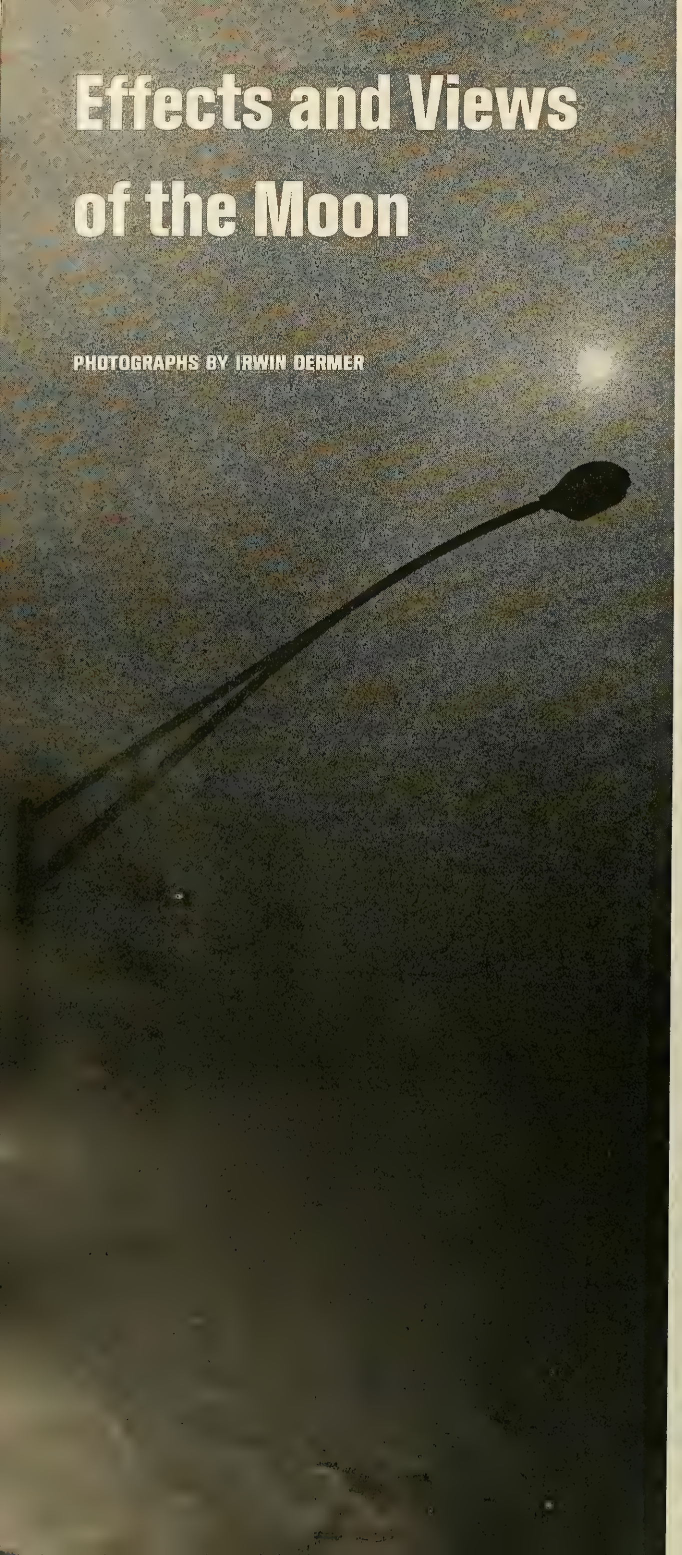
THIS queen of *Aenictus laeviceps* is 8.1 mm. long when in contracted condition typical of the nomadic phase.

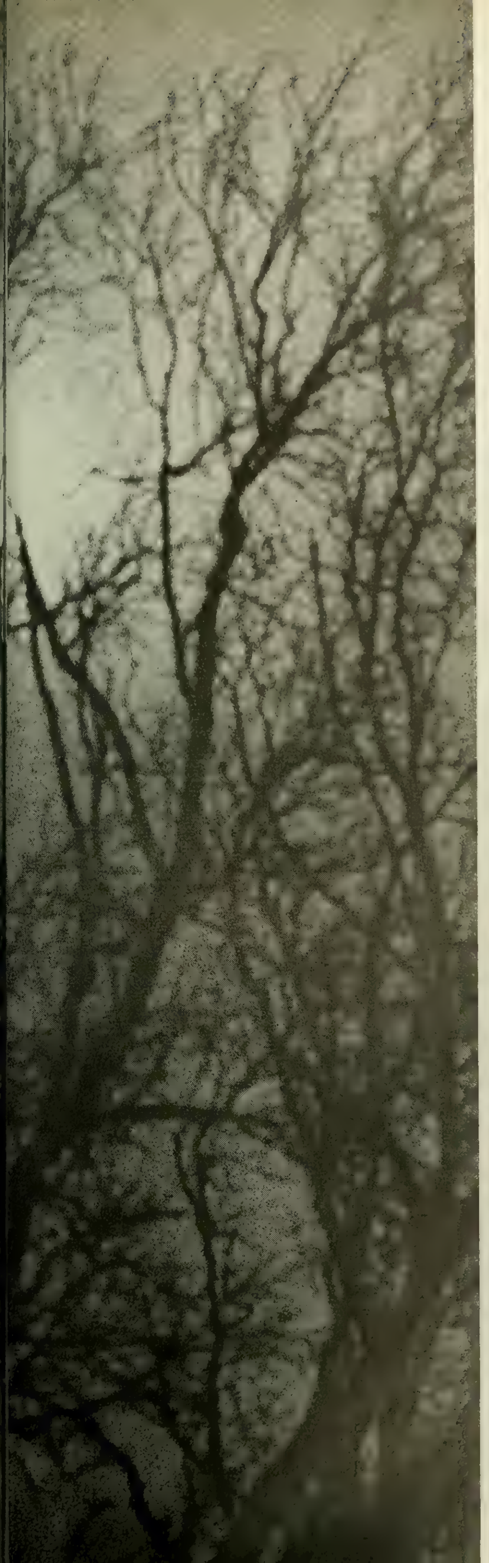


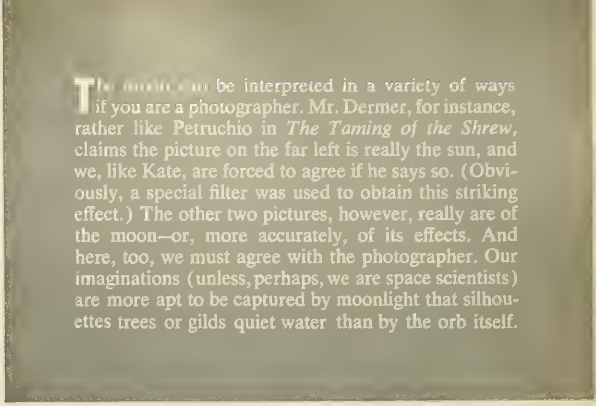
EARLY in statary phase, *right,* the queen becomes gravid and takes on physogastric condition of egg production.

# Effects and Views of the Moon

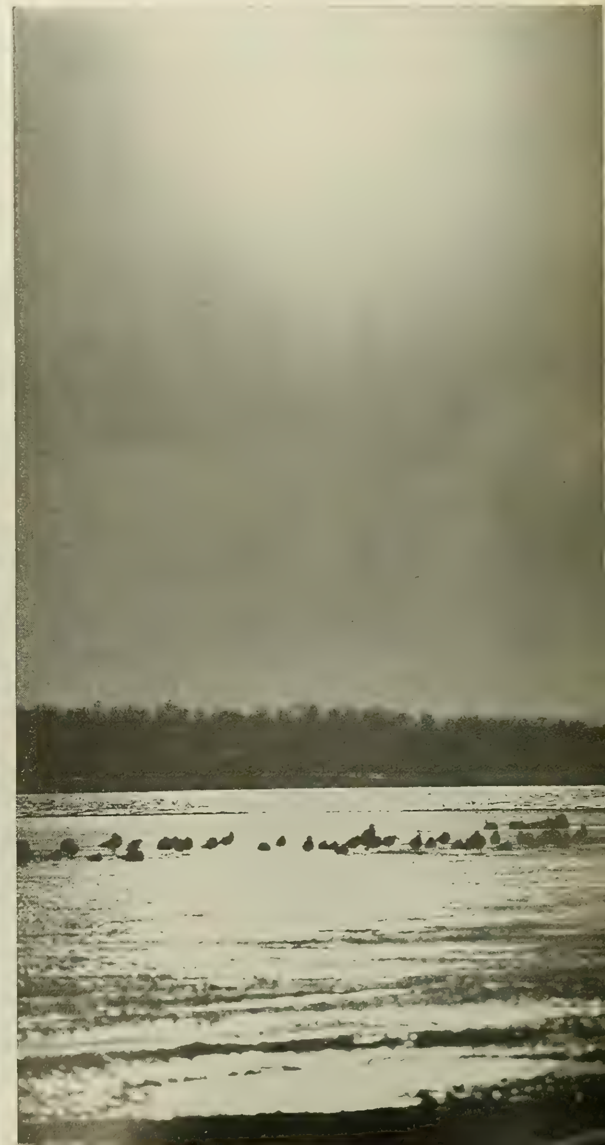
PHOTOGRAPHS BY IRWIN DERMER







The moon can be interpreted in a variety of ways if you are a photographer. Mr. Dermer, for instance, rather like Petruchio in *The Taming of the Shrew*, claims the picture on the far left is really the sun, and we, like Kate, are forced to agree if he says so. (Obviously, a special filter was used to obtain this striking effect.) The other two pictures, however, really are of the moon—or, more accurately, of its effects. And here, too, we must agree with the photographer. Our imaginations (unless, perhaps, we are space scientists) are more apt to be captured by moonlight that silhouettes trees or gilds quiet water than by the orb itself.



HEAVY dust accumulation, blown from eroded neighboring areas, covered a Morton County, Kansas, farm in 1939.

# Reality of Drought Is Always With Us

### By HAROLD E. THOMAS

IN our culture, *drought* is like those words used by Alice in Wonderland that mean what Alice chooses them to mean: its chief limitation is that it implies dryness. For example, power plants along the Columbia River have been said to suffer from drought when the basin is in such a deep freeze that river flow is minimized. A municipal water system that has a large river to draw from suffers from drought during a heat wave because people water their lawns more than usual, and rationing is necessary because pumps or pipes are insufficient to handle exceptional demands. In New Jersey an all-green field of spinach yielding six tons per acre has suffered from "hidden" drought, because it would have yielded eight tons if water had been available for maximum growth. In Arizona three adjacent areas have similar soil, and each has received two inches of rain during the growing season: one, covered with creosote bush, is doing normally; another, irrigated from wells, has an excellent crop; the third, with dry-farmed wheat, is suffering from drought. All these usages of the word are accepted in our culture. I see no way of developing a scientific definition that the public would accept to the exclusion of their existing usages. In other words, one cannot define drought as a hydrologic phenomenon alone, because in so many aspects it may also be a cultural phenomenon.

In a recently published report on drought in the southwestern United States, I use a definition that emphasizes the natural aspects but does not ignore the cultural ones: drought is a meteorologic phenomenon that occurs during a period when precipitation is less than the long-term average, and when this deficiency is great enough and continues long enough to hurt mankind. Drought is thus measured in terms of the duration and magnitude of the departure from the average climate in the area under consideration. We cannot say that droughts are "unexpected," especially in places where there is a history of recurring droughts, but neither do we yet have the wisdom to predict them. On the other hand, they are exceptional, not usual, events.

The dryness of a region with a low average precipitation is termed "aridity." As C. W. Thornthwaite has pointed out, an arid climate is one in which the average precipitation is significantly less than the potential evapotranspiration, or the rate at which solar energy could cause return of water from the earth to the atmosphere if the water were available. The regions of greatest aridity — the deserts — are readily identifiable, and the few plants and animals that live in them are necessarily adapted to the perennial scarcity of water. In arid lands, as in other regions, drought occurs only

when the precipitation is significantly less than the long-term average.

This distinction between aridity (characterizing certain geographic regions on the basis of the average conditions of the climate) and drought (characterizing certain time periods on the basis of deviations from these averages) is widely recognized, but by no means universal. Some dictionaries include aridity among their definitions of drought, and some people describe deserts as regions of "permanent drought." But "water shortage" is the best term to use where we do not or cannot discriminate the cause of insufficiency of water to meet the needs or desires of man. This all-inclusive term may be applied to natural deficiencies such as lack of rain or drying up of soil, spring, creek, or pond, whether because of drought or aridity. It may refer to a man-made predicament: a shortage of pure, clean, hot, or ice water, or a shortage of water in a fifth-floor apartment or at the end of a long, small pipeline. Or water shortage may result from excessive human demands upon a limited natural supply. A large proportion of our troubles with water falls in the broad category of water shortages, and since we and our demands are multiplying, whereas the natural supplies of fresh water are not, prognosticators foresee aggravation of these problems in the future.

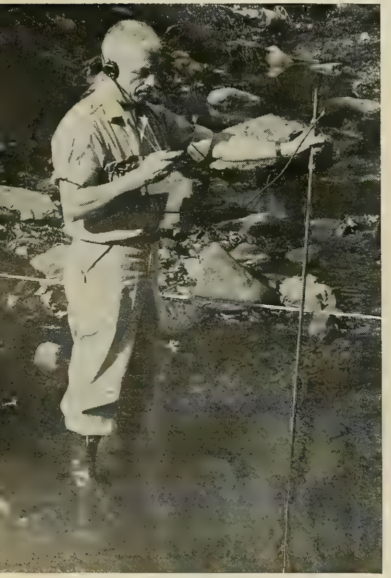
Now to the cultural phenomenon of drought. Although precipitation is recognized as the ultimate source of practically all the fresh water on the continents, little life is sustained by precipitation alone. People and living organisms generally have continuing need for water after rain ceases, and they meet these needs—even while it is raining—by drawing upon soil moisture, ground water, or surface water left over (stored) from some previous precipitation. Thus, in terms of human needs, dryness or lack of water cannot be defined solely on the basis of such climatic factors as precipitation, temperature, atmospheric humidity and pressure, wind velocity, and evaporation. But variations in these factors have effects upon the various sources of water—soils, lakes, streams, springs, and surface and underground reservoirs—upon all or some of which man depends for his supplies.

Let us glance at the effects of precipitation and non-precipitation on these various sources. When it rains, water accumulates in the soil, insomuch as it can be infiltrated and retained; the excess accumulates on the surface, runs off, or moves downward to accumulate as ground water; the storm runoff may accumulate in lakes or reservoirs or in rivers where it may create floods; surplus storm water may eventually be discharged into the sea. When it is not raining, the water accumulated in the soil is depleted by evaporation and plant use; the accumulated ground water is discharged by springs or phreatophytes or by seepage into streams, where it constitutes the dry-weather or base flow; the water accumulated in lakes, reservoirs, and ponds is depleted by evaporation or by outflow to streams; the rivers continue to discharge into the sea. Clearly, in a drought the forces of depletion are working on all these sources where water has accumulated from precipitation. However, the effects of drought may appear quickly at some sources and after long delay at others; at some, they may be pronounced, and at others, too slight to be noted. Thus, the effects of drought may be mild, moderate, severe, or extreme, depending upon the extent to which a drought reduces the supplies with respect to the developed demand.

My grandfather, farming half a century ago in southwestern Michigan, was easily hurt by drought. After two weeks of summer heat and cloudless skies, his crops stopped growing and started wilting. His particular water shortage was one of soil moisture, and he looked to the skies and to rain clouds for relief. His definition of drought would be similar to that developed in the British Isles, which has a similar humid climate: a partial drought is a period of more than twenty-eight days with a small rainfall per day, and an absolute drought is a period of at least fifteen consecutive days when rainfall is .01 inch or less. The soil-moisture deficiency that results from such droughts occurs during the growing season and specially when vegetation requires the most water; the deficiency may be alleviated by a single storm and generally does not persist through the following winter dormant season. If such a summer drought continues long enough, other water supplies on farms are affected: some stock ponds, creeks, springs, and dug wells may go dry, and it may be necessary to haul water for stock. Such droughts have frequently been described as "agricultural droughts."

THE effects of drought upon soil moisture may be more difficult to erase in regions of less humid climate, and particularly in those regions where the potential evapotranspiration is as great as, or greater than, the average precipitation. A current example is in the High Plains, extending from southeastern New Mexico and the Texas Panhandle northward to western Nebraska. In January and again in February, 1965, high winds created dust bowl conditions reminiscent of the 1930's in an area where soil and sul soil were bone-dry because rainfa had been far below average sinc 1963. This drought is still continuin as of May, 1965, and, according t Garald G. Parker of the U. S. Geological Survey, the drought-affected are covers about half the area of th March, 1936, dust bowl. Aside fro the smaller size of the area, the chie difference in the current drought i in the people's awareness that drough is a part of their climate. By soil an water conservation practices, man farmers hold the topsoil in place b maintaining a vegetative cover o their lands, and they produce crop and maintain moisture in the soil b means of irrigation from pumpe wells or from surface water—whe such is available.

My grandfather's farm was traversed by a creek that never went dry but we never knew how the flow wa affected by drought, for this creek represented only an obstacle to grandfather. Nowadays many farmers i humid regions pump water from suc creeks, or from rivers or wells, and irrigate their crops during periods o deficient precipitation. By thus developing reserves of surface water o ground water, these farmers are n longer utterly dependent upon th



POTOMAC RIVER flow rate is checked by U.S. Geological Survey hydrologist.

storage of water in the soil, which drought can deplete so quickly. But now it has become important to them to know the effects of withdrawals by them and by others, as well as the effects of drought, upon these surface- and ground-water resources. In other words, they have become concerned with the effects of drought on all phases of the hydrologic cycle and on all the water resources.

In the arid Southwest, on the other hand, a rainless month, or even an entire growing season without rain, does not qualify as a drought, because these are usual occurrences. The pioneers quickly learned of the prevailing soil-moisture deficiency throughout most growing seasons. For successful agriculture they had to supply additional water to the soil by drawing upon springs, streams, and wells — surface water and ground water that came from precipitation at other times and other places, winter snows in the mountains, for example. In arid regions, then, a farmer may be dependent upon, and is therefore interested in, many aspects of the water resources in a broad region: snow catch in mountains, annual freshets (which may be stored in reservoirs), streamflow throughout the growing season, and ground-water recharge and discharge, in addition to the actual precipitation upon his land. In drawing from the total water supply he is in competition with cities and industries that also use water or, let us say, that have a common interest in obtaining optimum benefit from the natural resources. All water-users endeavor to achieve security against the seasonal and perennial deficiencies that are usual in their particular localities, and if the total water supply is seriously reduced during several years of less than average precipitation, that is a drought. These are sometimes called "water-supply droughts."

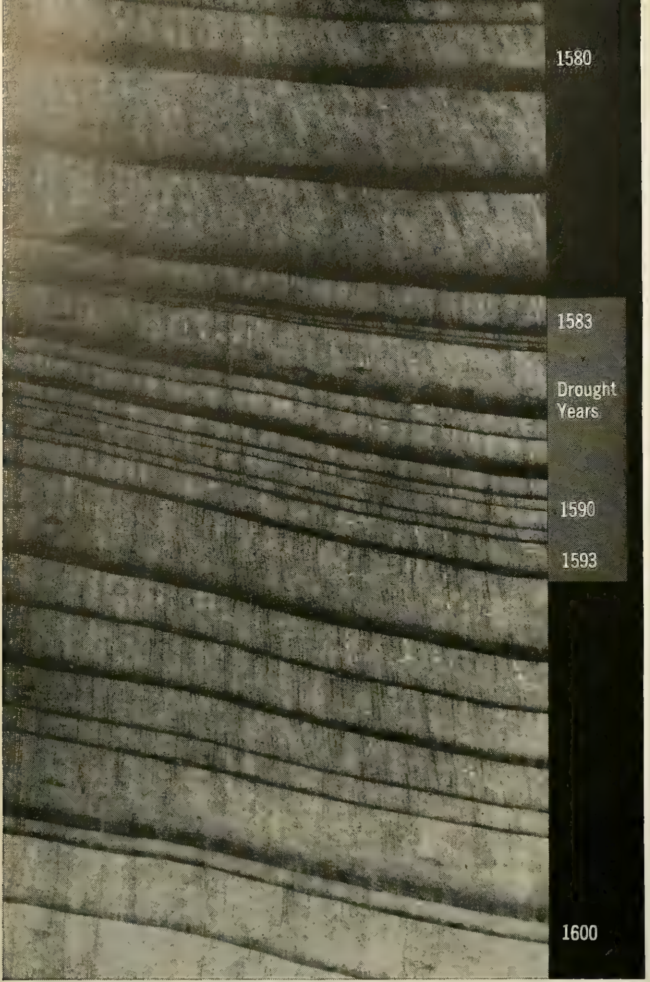
In several parts of the Southwest the climatic history is comprised of a succession of alternating wet and dry periods of irregular length, but with average durations of ten to thirteen years. Characteristically, these alternations are most prominent in regions where the precipitation is chiefly from a single source, as along the Pacific border, where moisture comes from the Pacific Ocean, and in the Great Plains, where moist air masses come chiefly from the Gulf of Mexico. In both these regions the precipitation deficiency during a ten- to thirteen-year drought period may be equivalent to as much as three years of average precipitation. Recurrent drought periods are pronounced in some localities, fairly clear at others, and not recognized at still other places.

In the intervening region, which includes the Great Basin, Colorado plateaus, and the Sonoran border, droughts are less regular in duration, recurrence interval, and magnitude. This area receives its annual precipitation from several sources, but in various sections one source is likely to be dominant in some seasons, and a different source dominant in others. Analysis of precipitation by seasons makes it possible, at least in some localities in this intervening region, to discriminate drought periods with recurrence intervals similar to those observed either in the Pacific or Great Plains regions.

Records of tree growth indicate that during the past two thousand years there have been droughts of exceptional magnitude in various parts of the Southwest, notably in the central Pueblo area of northern New Mexico and Arizona in about A.D. 700-720, 1070-1100, 1275-1300, and 1570-1600. These exceptional twenty- to thirty-year droughts may be the products of centuries-long climatic fluctuations, augmented by the shorter-period fluctuations noted in the records for the

**Exposed banks** dramatize drop in the water level near Washington in 1964.

**"Drought rock,"** at rear, is visible only when Potomac flow is below normal.



**Tree ring series from a Douglas fir collected in northern Arizona shows that area suffered a severe drought in ten years between 1583 and 1593.**

last century. As such droughts approach the span of a generation, they raise the question: are we undergoing a permanent climatic change?

Studies of the variations in natural streamflow indicate similarities in pattern over broad regions that correspond approximately to the principal regions of the Southwest just mentioned. These studies are based upon records of eighty-five stream-gauging stations, well distributed throughout the Southwest, where natural runoff has been least modified by man. The streams in extensive areas have similar runoff characteristics, and fluctuations of runoff reflect in large part the meteorological fluctuations in the region. For the Southwest as a whole, tree-ring studies indicate a probability that mean runoff during the base period 1904-53 was close to the mean runoff for the 154-year period 1800-1953, and also for longer periods of as much as 850 years.

The studies of drought in the Southwest were based upon a great variety of data on all aspects of water resources, on all phases of the hydrologic cycle, and on many types of terrain in many stages of development throughout the southwestern states. Only in the records of precipitation and of streamflow unmodified by man did we find satisfactory bases for analysis of the natural phenomenon of drought over the region as a whole. Many other data show the effects of drought at specific localities — upon spring discharge, water levels in wells, reservoir storage, or water quality, for instance—but these effects are so generally modified by man's activities, or by the environment, that direct comparison of drought effects from one place to another is impossible. In some localities the natural supplies have been clearly reduced by drought and in others no such reduction is apparent; in some areas the effects of drought have been ameliorated and in others aggravated by man's activities; and in some places human activities, rather than the natural factor of drought, must be held responsible for present or future water shortages.

In general, storage and regulation of the fluctuating natural supplies are prerequisite to providing assurance of a firm supply to meet water requirements. For amelioration of the effects of the long-period droughts of the West, this is best accomplished by regulation of surface reservoirs with capacity sufficient for holdover storage, and by management of ground-water reservoirs. Planning for adequate water supplies to last through a dry period that may continue for several years is a big step beyond planning for adequate supplies for a dry summer following a wet winter, but still it is a step in the same direction, and similar principles and techniques may be applicable. As details of such a long-range plan are worked out and put into operation, the periods of greatest precipitation deficiency — the meteorologic droughts—become the tests to determine the adequacy of the planning. If the deficiency is greater than has been experienced in the past century, some downward revisions may be necessary in previous estimates of the resource. We may well be able to predict with greater accuracy the natural succession of wet and dry periods than we can anticipate the increasing requirements of man.

In the preceding discussion the short droughts have been associated with humid regions, where the average climate yields a water surplus. The deficient precipitation during drought is quickly reflected in soil-moisture deficiencies and, perhaps, in other water resources, but generally a drought merely reduces the normal surpluses that run off to the oceans. The long droughts have been associated with arid regions, where water deficiency is typical of the average climate. A short drought would augment this deficiency, but the inhabitants of arid regions protect themselves by finding and depending upon the occasional or local surpluses. A drought becomes critical only when it is sufficiently severe and prolonged to cut down or cut off these supplies. In our conventional wisdom, therefore, we draw a distinction between droughts in humid and in arid regions: the normal deficiency of arid regions insures that man will protect himself also against short seasonal deficiencies of unusual magnitude; the normal surpluses of humid regions insure that most droughts will be contained within a single year.

BUT now comes an unusual event in an area extending from New England to Virginia—deficiencies in soil moisture in each of several successive growing seasons, and generally downward trends in ground-water levels and in streamflow in a period now approaching four years in duration. This has all the earmarks of the prolonged droughts in arid regions except, of course, that sizable surpluses continue to run off to sea, for the rainfall even in drought is far greater than the average rainfall in an arid region. I am indebted to John E. McCall of the U. S. Geological Survey for data concerning this drought, particularly in the Delaware River Basin, which is within the area that is most affected.

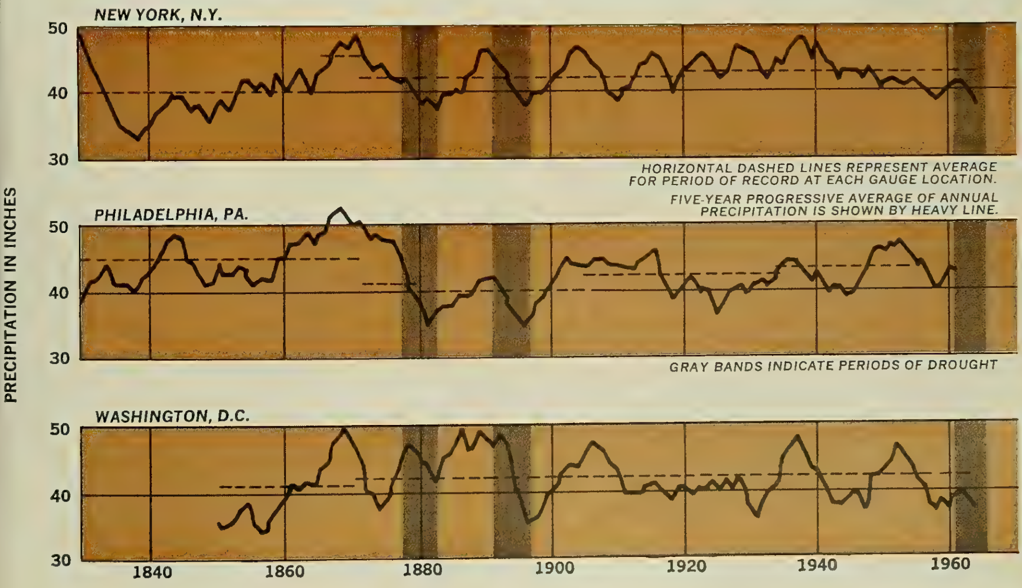
The average annual precipitation in the Delaware Basin usually exceeds forty inches and is distributed throughout the year, with about four inches in each month of the growing season, dropping toward three inches in the winter months. But rainfall was less than 50 per cent of average in September and October, 1961, in May and July, 1962, and in April and October, 1963. In the twenty intervening months the precipitation was less than average in all but five months, so that by November, 1963, the cumulative deficiency was about twenty inches, or half of a normal year's rainfall.

Soil moisture was extremely deficient by May, 1962, and continued so through September. The facilities of many water companies were overtaxed as numerous landowners resorted to lawn watering and irrigating of crops, and water levels in many wells declined sharply. The effects of drought were again apparent early in 1963, highlighted by numerous forest fires in April, and by applications from many counties for federal crop disaster assistance by mid-June. Soil-moisture deficiencies continued throughout the growing season and into the practically rainless month of October. They were erased by the heavy rains of November, 1963, and January, 1964. But before these rains came, hundreds of domestic and many municipal wells had gone dry, water was rationed in countless communities, and the natural flow of the Delaware River at Trenton in October, 1963, was the least of any October in fifty years of record.

The drought continued in 1964, and began setting new records. Precipitation was about half of average throughout the growing season, with resulting deficiencies of soil moisture and a consequent heavy draft on wells, streams, and municipal systems for crop irrigation and lawn watering. Rains in late November replenished the soil moisture, but ground-water levels in many areas were at record-breaking low levels, and some well drillers were booked up for six months or more to deepen old wells or drill new ones. Streamflow was generally far below average. If it had not been for the reservoirs in the headwaters of the Delaware River, the November, 1964, flow at Trenton would have been 27 per cent less than the previous record low flow of 1915.

As this article is being written—June, 1965—the drought is still continuing, and is especially severe in New Jersey and southeastern New York. Soil moisture had been replenished by rains in December, 1964, but precipitation was so far below average

TRENDS IN PRECIPITATION AT THREE CITIES AS SHOWN BY FIVE-YEAR PROGRESSIVE AVERAGES



throughout the spring that farmers began irrigating some crops during May. Whether the agricultural drought in 1965 is more severe than in preceding years will depend on whether rains in the next few months alleviate the existing soil-moisture deficiency.

Water resources other than soil moisture are showing the cumulative effects of prolonged drought: streamflows near the minimum of record for June, water levels in wells below the seasonal norms, and municipal reservoirs holding far less water than is usual at this time of year. Even with normal summer rains, water shortages are anticipated in many places, and scores of cities have already begun rationing and imposing selective bans on water use.

GRAPHS on the page opposite show some of the cumulative effects of the drought. From August, 1961, to June, 1965, the total precipitation deficiency (below the long-term average) in the upper Delaware Basin was nearly thirty-eight inches—almost an average year's supply. (In the same forty-five months the deficiency in flow of the Delaware River at Trenton was more than a year's average flow.) In the lower graph, the unshaded area, whose pattern is repeated each year, shows the range between greatest and least monthly flows during forty years preceding the current drought. For example, the upper margin in the space for January represents the highest January flow of record, and the lower margin represents the lowest January flow of record. Similarly, other parts of the unshaded area represent highest and lowest flows of record for other months. The dashed line represents the median flow: in half the years 1931-60 the measured flow has been above this median, in the other half, below it. The heavy line—adjusted for known artificial changes in order to approach the natural flow more closely—shows that the river has been setting new records for minimum monthly flow in 1962, 1963, and 1964, and is likely to set even lower records in 1965.

How exceptional is this prolonged drought in the East? According to Wayne C. Palmer of the U. S. Weather Bureau, by the end of 1964 in an area extending from Virginia to Vermont, it had become the longest drought period in at least forty years. The severity of the drought is indicated by its effect upon streamflow: numerous rivers have dropped to the minimum flow in forty or fifty years of record, lower than in the early 1930's, when precipitation was markedly below average in extensive areas.

There may have been droughts as long and severe as that of 1961-65, back in 1879-83 and again in 1892-96. This suggestion comes from a study of the records of precipitation at New York City, Philadelphia, and Washington, D.C. The graphs on page 55 show the trends in precipitation, as indicated by five-year progressive averages. There are several low points on the graph for each city, which may indicate culminations of droughts in the preceding five years. In several instances, downward trends are contemporaneous in two of the graphs, but not in the third. For example, the New York and Washington records indicate a drought culminating in 1931-32, but this is not evident in the Philadelphia record. All three graphs trend downward in the periods 1879-83 and 1892-96, and during these years precipitation was generally less than average in all three cities. Unfortunately, we cannot prove the existence of prolonged severe drought from these records, because the records are not homogeneous—the gauge locations have been changed several times at each city, and cities have grown up around them and probably altered the microclimate, with the result that some of the indicated "trends" may actually be due to our inconsistencies in gauging the precipitation.

Ivan R. Tannehill, at the conclusion of his excellent book, *Drought, Its Causes and Effects,* says, "Droughts are not mere chance occurrences; they are part of a physical process which can be measured and studied and predicted with increasing precision as our observations of the sun and upper air and the oceans continue to accumulate." Earlier he had pointed out that if one fact stands out in his study, it is that each local area must solve its own drought problem, because the causes of rainfall are not the same in all parts of the earth, and therefore the causes of rain deficiency will not be the same.

A first step toward understanding droughts is to describe the phenomenon properly. Recently Wayne Palmer has developed a general methodology for evaluating the meteorologic anomaly in terms of an index, which permits time and space comparisons of drought severity. As another method of approach, F. A. Huff and S. A. Changnon, Jr., of the Illinois State Water Survey, have analyzed the frequency distribution of droughts in Illinois for periods of three to sixty months. Climatic analyses such as these will permit us to obtain figures on drought severity expectancy. A long road remains ahead toward prediction and, perhaps, limited control; prerequisites here are major efforts in atmospheric research and atmospheric surveillance. Even if we are never able to control climate, much will be gained if we know what to expect and, as a result, take necessary steps to prepare for emergencies.

Severe droughts are infrequent, and it is easy for mankind to be lulled into not expecting them at all. Particularly is this true in humid regions, where water is sufficiently abundant to allow continuous runoff of the surplus to the oceans. But in many places people, with their increasing requirements for water, are cutting into this surplus in numerous ways. Superimpose upon this the effects of the infrequent, but nevertheless inevitable, severe drought, and the stage is set for water shortages. But so long as surpluses continue to exist at other times or places the foresighted can reserve some of these surpluses for use in the emergency of drought. This is essential in water-resource planning.

WHETHER mankind ever overcomes the effects of drought will depend upon the definition of the term. If droughts are defined solely as natural events—the parts of climatic fluctuations, of whatever duration, that are prevailingly below the average—such droughts are likely to be as numerous and varied in the future as they have been in the past. If the ability to hurt man is accepted as an essential element in drought, then as man utilizes a progressively greater proportion of the total resource he becomes more vulnerable to natural deficiencies, and droughts may become progressively more severe. On the other hand, as man learns more about the magnitude and frequency of climatic fluctuations, he can insure against deficiencies by astute planning, until ultimately a large proportion of these events might pass without casualties; the many definitions of the term drought could then be dropped and the word's use be restricted to those events that are too rare and too costly to guard against.

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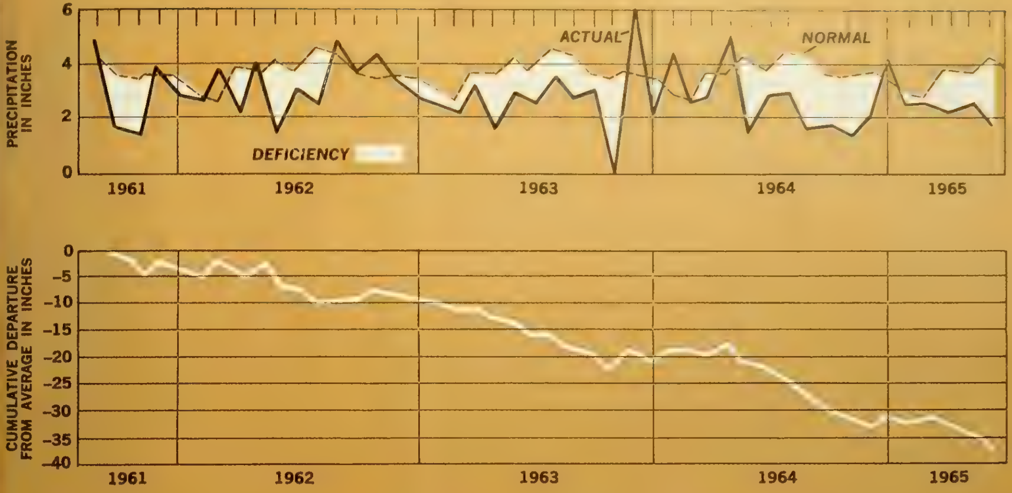
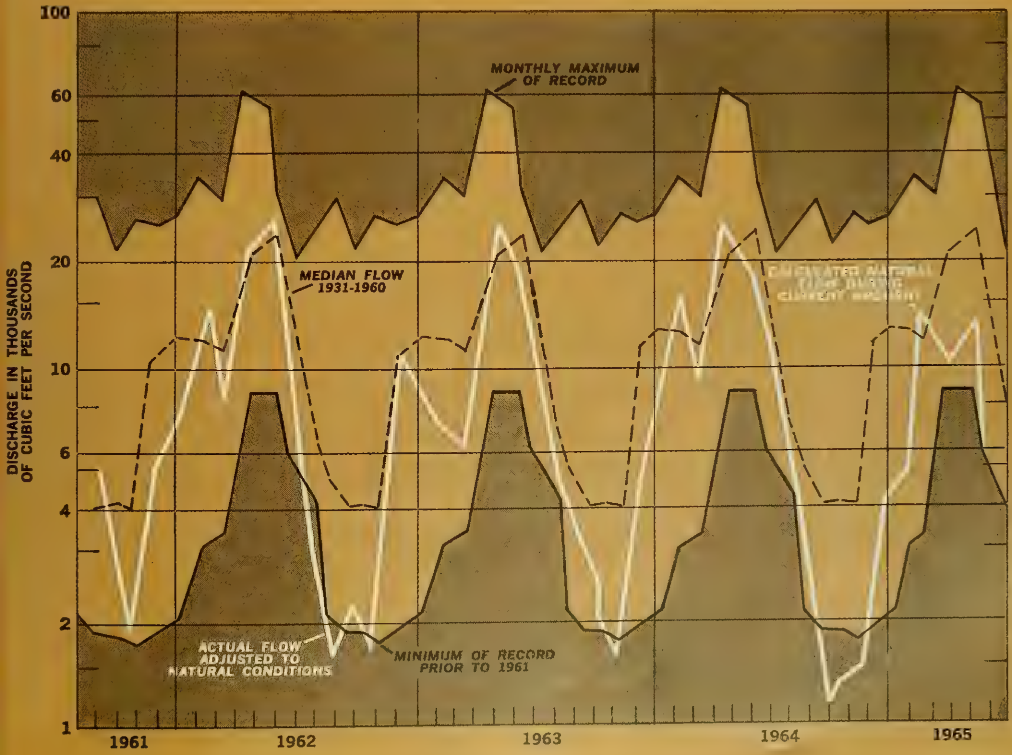


MONTHLY STREAMFLOW OF THE DELAWARE RIVER AT TRENTON, N.J.



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# About the Authors

E. S. Higgs, author of "Search for Greece of the Stone Age," is Curator of Prehistoric Animal Remains at the Museum of Archaeology and Ethnology, Cambridge University, England. He established the Department for the Study of Organic Material there in 1957, and has been Senior Assistant in the University's Department of Archaeology and Anthropology since 1962. He has directed and codirected many archeological excavations in England, North Africa, and Greece, and is a Scientific Fellow of the Zoological Society of London.

Dr. Celso Paulo Jaeger, who wrote the article on giant snails, is Assistant Professor of Zoology at the University of Rio Grande do Sul, Brazil. His major research is on the roles of neurosecretory substances as agents that mimic and supplement neurotransmitter actions.

The author of "Brown Pelican Is Victim of Gull Piracy," Dr. Andrew J. Meyerriecks, is an Associate Professor of Zoology at the University of South Florida in Tampa. He specializes in research on the biology of herons and other wading birds. His brother, Robert, took the photographs for the article.

"Dorylines: Raiding and in Bivouac," Part II, concludes an article on legionary ants begun in the October issue. The author, Dr. T. C. Schneirla, is Curator in the Department of Animal Behavior at The American Museum. His research interests include orientation and communication in ants, insect learning and instinct, and a study of the comparative psychology of learning.

W. Gurnee Dyer, author and photographer of "Guelta of the Bleak Sahara," has, during the past three years, spent six months in Africa taking pictures, making tape recordings of music, and collecting artifacts for The American Museum. Thirty of his photographs were shown at the 1965 International Photographic Exposition in the New York Coliseum, and many artifacts he collected were exhibited in the African Pavilion at the 1964-65 New York World's Fair. For many years he has been associated with Clark, Dodge, and Company in New York City.

Dr. Harold E. Thomas, author of the article on drought, is an international authority on water conservation, arid-zone hydrology, drought and economics, and ground-water law. A research geologist with the Water Resources Division, Geological Survey, U.S. Department of the Interior, he has spent the major part of more than thirty years studying ground water in the West and Southwest, and has written many articles and books on the subject. He was one of the chief authors on the Lake Mead sedimentation study, the most complete analysis ever made of a major U.S. reservoir.

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**PORTRAIT IN SCIENCE**

# Jefferson's avocation

### By Lowell D. Holmes

In Thomas Jefferson's day there was no discipline known as anthropology. The first anthropological museum was not founded in America until 1866, and the first American professor of anthropology was not appointed until 1886. However, the eighteenth and nineteenth centuries witnessed the development of a group of talented amateurs—doctors, lawyers, natural historians, businessmen—for whom interest in primitive man was a hobby. To the growing fund of information about primitive man they applied common sense, the methods of their own professions, and current scientific theories.

Thomas Jefferson was such an amateur. He was a true child of the age of enlightenment, and his fertile mind was equally at home in politics, physics, astronomy, architecture, theology, music, education, and—although historians have largely ignored it—the study that is known today as anthropology.

Anthropology is best defined as the study of the whole man, and Jefferson was active in all the areas that make up this broad science. He had associated with Indians since childhood and developed a keen interest in their history, physical type, language, culture, and welfare. His greatest interest, however, was the comparative study of languages. He had dabbled in philology and etymology, and found the American Indian languages a fascinating new avenue for his interests.

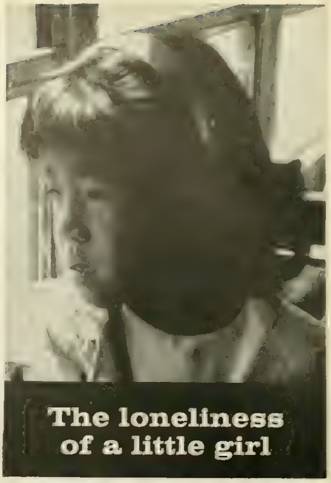
The origin of the American Indian was a much-debated question during the late 1700's. James Adair, the eighteenth-century Indian trader and author, believed that American Indians were one of the lost tribes of Israel, while a variety of other scholars postulated that they were remnants of the army Kublai Khan sent to conquer Japan; Tartars; Macedonians; or Carthaginians from Hanno's fleet. In all this confusion Jefferson withheld an opinion and wrote in 1800, "we can never get any information of the ancient history of the Indians, or their descent and filiation, but from a knowledge and comparative view of their languages."

To this end, he took advantage of every opportunity to collect vocabularies of Indian languages from traders, army officers, or anyone else who maintained intimate contact with the Indians, and requested basic word lists to add to his collection. Although he hoped to publish comparative material on the languages of about fifty tribes, his linguistic activities were curtailed in 1801 when he went to Washington as the third President of the United States. Then in 1809, when James Madison succeeded him in the presidency, Jefferson sent his personal belongings, including all his language manuscripts, to his estate, Monticello, by riverboat. The trunk containing the linguistic materials was extremely heavy and, believing that it must contain gold or some other form of currency, two boatmen broke into it and scattered the supposedly "worthless" papers. Some of the data were salvaged, however, and sixty-eight pages, containing vocabularies of two Algonquian languages, were deposited in the library of the American Philosophical Society, where they are today.

## Excavations

Jefferson was also deeply interested in the material products of American Indian cultures—arrowheads, pottery, and other artifacts—and his activities were not those of the souvenir hunter. To him, these products were clues to the solutions of historical problems. He was particularly interested in the large earthen mounds, called barrows, which had been found by the thousands from Canada to Florida, and from the Atlantic coast to the Ohio River Valley. The identity of the builders of these earthworks and the purpose of the structures were the primary archeological mysteries of Jefferson's day. Some scholars believed that an ancient race of mound builders had produced them. Jefferson maintained that they were the products of American Indians and that they served as burial mounds. While excavations of these earthworks had certainly produced great quantities of human bones, there were several theories as to their exact function. One theory held that the mounds marked the location of battlegrounds where bodies of slain warriors were covered with earth where they fell. Another suggested that the mounds were village sepulchers where individuals were interred in orderly rows of graves. A third maintained that the mounds were places of secondary burial, where large numbers of bones, collected from other graves, were deposited and covered over.

Jefferson wanted to investigate this problem as scientifically as possible. In *Notes on the State of Virginia*, written about 1781, but not actually published until 1787, he describes the methods he used in excavating a large mound near Monticello. First, he dug sample pits in various parts of the mound to see if it actually contained bones or artifacts. The



**The loneliness of a little girl**

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initial probings produced large numbers of bones that had apparently been unceremoniously deposited without any attention to order. This indicated that the third theory—that of periodical mass depositions of bones—could be the correct one, but Jefferson was not satisfied with such fragmentary evidence. The next step was to dig a sample trench down the middle of the mound. This technique, often used by modern archeologists, provides a random sample of the site's contents and, at the same time, allows the archeologist to note the various strata, or levels, that make up the site. As there is no earlier reference to this method in the literature, we must assume that Jefferson was among the first to utilize this concept of stratigraphy, which is today a key method of excavation and a major criterion of the scientific nature of any archeological research.

Jefferson's efforts revealed four strata of bones in some areas of the barrow and three in others. He uncovered them without disturbing their position, and a careful examination of their condition was made at the various levels. The bones at the bottom were apparently older, because they were more decayed than those at the top. There were skeletal remains of about one thousand individuals in the mound, many of them children. The bones were assembled oddly, and none appeared to have been damaged by bullets or arrows. This evidence ruled out the theories of battlefields and orderly primary burials and established the belief that the mound had been built up from periodic secondary burials of large numbers of bones. Thus, through controlled, scientific methodology Jefferson resolved a long-standing controversy on one aspect of North American prehistory.

## Ethnographic Research

According to modern definitions, Thomas Jefferson was both an ethnographer and an ethnologist. (Ethnography is descriptive anthropology and ethnology is the comparative study of custom in living cultures.) In his role as ethnographer he was interested in the observation and description of individual primitive cultures. Prior to his journeys among foreign or primitive people, he prepared himself in the manner of the modern field ethnographer by reading all the available publications dealing with the peoples he was to encounter. It is more for his encouragement of ethnographic research than for his own activities, however, that tribute should be paid to Thomas Jefferson. One of his initial acts as President of the American Philosophical Society, a position he held from 1797 to 1815, was to form a committee that sent letters to persons who associated with American Indians, requesting information concerning "the Customs, Manners, Languages, and Character of the Indian Nations, ancient and modern, and their migrations."

Jefferson was also largely responsible for the ethnographic data on American Indians that were collected by the Lewis and Clark Expedition. In the orders he gave Meriwether Lewis in 1803, he requested answers to such questions as: "How long do the women usually suckle their children?" "Do they eat the flesh of their prisoners?" "Have they any music, and what are their musical instruments?"

Commenting on Jefferson's list of questions, the American anthropologist Clark Wissler wrote in 1943, "He gave full directions for the recording of ethnographic data, surprisingly modern in tone, which might even now serve as a guide to the field worker. This document is not famous like Jefferson's draft of the Declaration of Independence but it shows the same masterful grasp of fundamentals, for he fully sensed the modern field worker's job."

As a theorist, Thomas Jefferson greatly resembled the scholar Franz Boas (1858-1942), who is commonly referred to as the "Father of American Anthropology." Boas was hesitant in making generalizations about the nature of man and insisted that the anthropologist's job was to observe and record until sufficient data were available to warrant valid theories. Thomas Jefferson showed similar restraint. Instead of prematurely advancing a theory of the origin of the American Indian, as did many of his contemporaries, he spent long years collecting vocabularies and data about Indian customs and physical types, hoping that he might ultimately establish a scientifically derived truth. In a letter to Charles Thomson, the Continental Congress secretary, in 1787, Jefferson asserted that "the moment a person forms a theory, his imagination sees, in every object, only the traits which favor that theory." In *Notes on the State of Virginia* he wrote, "A patient pursuit of facts, and cautious combination and comparison of them, is the drudgery to which man is subjected by his Maker, if he wishes to obtain sure knowledge."

Jefferson sometimes did derive conclusions from inconclusive evidence or find himself unable to dispose of preconceived ideas, but these cases were few. One insufficiently documented generalization was his formulation of a conjectural history for North America, delineated in a letter to William Ludlow in 1824. It read:

"Let a philosophic observer commence a journey from the savages of the Rocky Mountains eastwardly towards our seacoast. These [savages] he would observe in the earliest stage of association living under no law but that of na-

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ture, subsisting and covering themselves with the flesh and skins of wild beasts. He would next find those on our frontiers in the pastoral state, raising domestic animals to supply the defects of hunting. Then succeed our own semi-barbarous citizens, the pioneers of the advance of civilization and so in his progress he would meet the gradual shades of improving man until he would reach his, as yet, most improved state in our seaport towns. This . . . is equivalent to a survey . . . of the progress of man from the infancy of creation to the present day."

## Concept of History

It will be observed that in Jefferson's concept the history of mankind had been one of evolution and progress from a state of savagery to barbarism to civilization. This idea could well have been derived from the Scottish "Science of Man" philosophers—Lord Kames, David Hume, and Adam Ferguson—but would be rejected by most anthropologists today because it attempts to explain all cultural developments by oversimplified formulas. Anthropologists usually avoid judgments on morality and ethics, and it is a rare anthropologist, indeed, who believes he can judge the values of the society he is studying by the standards of his own culture. Rather, he recognizes that an act that is completely immoral in one society may be considered right and good in another. This philosophical position has come to be known as cultural relativism, and there is evidence that Thomas Jefferson was a bit of a cultural relativist himself. In 1814, in a letter to Washington economist Thomas Law, he wrote, "Men living in different countries, under different circumstances and regimens, may have different utilities; the same act, therefore, may be useful, and consequently virtuous in one country which is injurious and vicious in another differently circumstanced."

A significant aspect of Jefferson's relativistic position was his concept of "circumstance." The majority of his contemporaries considered the American Indian as a savage, subhuman form who had not been able to achieve the blessings of civilization because he was mentally incapable. Jefferson was firmly opposed to this view, and in many of his writings he asserted that all men are much the same and that the differences in their levels of development may be accounted for by the circumstances surrounding their lives. He insisted, therefore, that facts about the American Indian be collected in the context of circumstances.

One of the great debates of Jefferson's life was with Comte de Buffon, the French naturalist, on the nature of the American Indian. Buffon maintained that the North American aborigines were sexually weak, unintelligent, and cowardly, with little ardor of soul and none

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of the "qualities that might make for the good life." He considered them inferior because they did not live up to European standards. Jefferson was quick to come to the defense of "his" people. He pointed out that the Indians excelled in traits useful to their survival, that they were not inferior but merely different, and that this was because they were products of a different cultural history.

## Controversial Views

WHILE Jefferson was less active in the area of physical anthropology, many of his views on the subject were just as advanced as in the areas already discussed. He believed, for example, that man was an animal—a view that was still revolutionary in Darwin's day, let alone in Jefferson's. Furthermore, Jefferson believed, as early as 1800, that man was merely an advanced species that had developed by minute gradations from one creature to another. Yet Lamarck's thesis, *Philosophie zoologique,* was not published until 1809, and Darwin's *On the Origin of Species* did not appear until 1859. Regardless of the sources of Jefferson's ideas, it is certain that they caused him trouble. One member of the clergy, Rev. Clement C. Moore, referred to his views as a "sweet sounding concert of philosophy and infidelity." The Rev. William Linn even went so far as to suggest that Jefferson should be disqualified for election because his intention was to make America a nation of atheists.

**DR. HOLMES is Associate Professor of Anthropology at Wichita State University. In research he has dealt mainly with Samoan cultural change.**

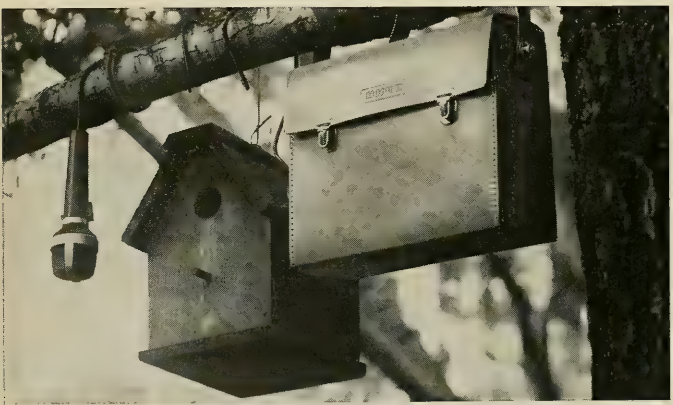
Jefferson's comparative analysis of language led him to believe at one time that American Indian languages were older than those of northeast Asia. He postulated that the American Indian was not a migrant from Asia but rather a subspecies of man, *Homo sapiens americanus*, which had evolved in North America. This, of course, was tantamount to a belief in polygenesis—the theory of multiple origins of man. In time, Jefferson re-evaluated his evidence and postulated that the American Indians had entered North America by way of the Bering Strait. This judgment was made on the grounds of both language identity and physical resemblance of American Indians and northeastern Asiatic peoples. This conclusion is surprising, because until recently linguists asserted that there was no relation between Indian languages and those of northeast Asia.

Jefferson was also a pioneer in the field of applied anthropology. He established the principle of using anthropological data in formulating a responsible administration policy for Indian affairs. He realized that Indian-white relations had been a shameful expression of the alleged superiority of civilized man, and advised frontier personnel as follows:

"After the injuries we have done them, they cannot love us, which leaves us no alternative but that of fear to keep them from attacking us. But justice is what we should never lose sight of, and in time it may recover their esteem."

In addition, in Jefferson's instructions to Lewis and Clark he revealed a far-sighted purpose in collecting ethnographic details about the aborigines of North America. Knowing there would be a time when the American Indian would have to give in to the advance of civilization, he felt that it would be "useful to acquire . . . knowledge . . . of the state of morality, religion and information among them; as it may better enable those who may endeavor to civilize and instruct them, to adapt their measures to the existing notions and practices of those on whom they are to operate."

Thomas Jefferson's visionary research methods and his role in promoting the collection and utilization of data about primitive cultures are particularly extraordinary because they antedated by a full century America's recognition of the science of man. Certainly he is prominent among our pioneers in anthropology.



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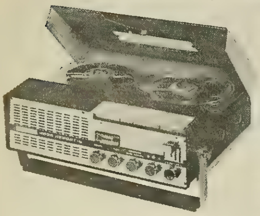

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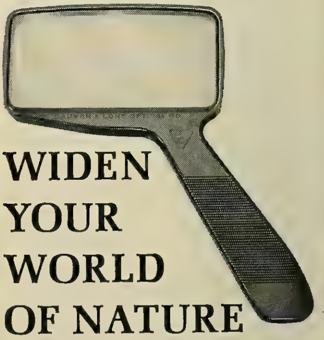

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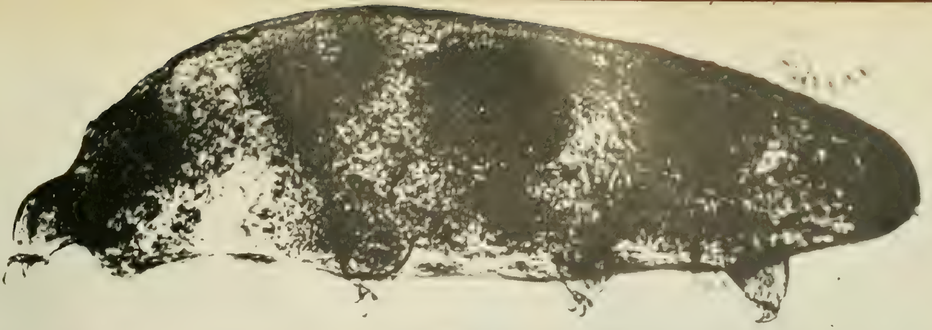
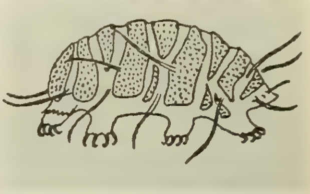
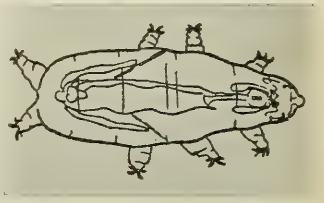


Tardigrades possess a ventral nerve cord with ganglia, a brain, eyespots, rudimentary Malpighian tubes, narrow esophagus, teeth, and wide mesenteron.





# COUSIN TO MITE AND SPIDER

## Tardigrades are arthropods of microscopic dimensions

By Linda J. Gandek and David Pramer

The tardigrade is an unusual animal that has stubby, claw-bearing legs; a conical snout; a bruin-like, lumbering gait; and is called a water bear. The analogy with Ursidae is, however, misleading. Water bears are tiny arthropods, seldom more than one hundredth of an inch long, and are thought by some to be distant relations of mites and spiders.

Water bears comprise the class Tardigrada, which originated early in the evolution of segmented worms and animals with jointed legs (phyla Annelida and Arthropoda respectively). The leading genera are *Macrobiotus* and *Echiniscus*. In some species, a constriction in the cylindrical body circumscribes the junction of head and torso. Other species are covered with armor plate that appears to separate the body into regions. However, tardigrades are soft-skinned, segmented animals, even though they show little external evidence of it. The animals are provided with four pairs of short, unjointed legs, each of which terminates in two or four claws. They move clumsily, with a deliberateness that is both awkward and appealing.

Tardigrades feed on minute organic particles. Papillae surround a mouth that contains a pair of horny, sometimes partly calcified, teeth, and the duct openings of two salivary glands. The animal has a muscular pharynx, a narrow esophagus, a wide mesenteron —central gastric cavity—and a subterminal anus that is situated just anterior to the last pair of legs. Rudimentary Malpighian tubes, two eyespots, a brain, and a ventral nerve cord with ganglia are present, but tardigrades have no organs of respiration or circulation. In some species, the mouth is provided with a stylet for sucking. Water bears feed on the juices of living plants, and they have been observed to attack nematode worms, using their stylets as lances to tear the surface of the prey, which is eventually immobilized and consumed. The sexes are separate, and tardigrades lay eggs that are thick-walled, spiny, or warty, and that hatch promptly on contact with water.

These arthropods are usually found in moist soil and in fresh water and marine environments. Aquatic species can be captured in plankton nets, and terrestrial species are abundant in damp moss cushions. Some means of attachment is commonly evolved by small organisms that feed by grazing in a watery habitat, and tardigrades are no exception. They have claws and, occasionally, long bristles to prevent their being washed out of moss cushions by heavy rains or dislodged by swift currents from the surface tangles of aquatic plants on which they feed. Eggs of many species are covered entirely with stickers that anchor them to the substrate, assuring the young of nourishment when they hatch.

One of the most interesting facts about the animals is their ability to withstand extreme desiccation and exposure to low temperatures. They contract, shrivel, and pass into an anabiotic stage during periods of dry weather. When water is again available, they swell and revitalize. There are records of the recovery of tardigrades after seven years of anabiosis, and they have survived temperatures as low as —272 degrees centigrade. Tardigrades can be washed from moss and their antics observed microscopically. It is regrettable that few people have ever heard of this engaging group of animals, and that fewer still have ever seen them.

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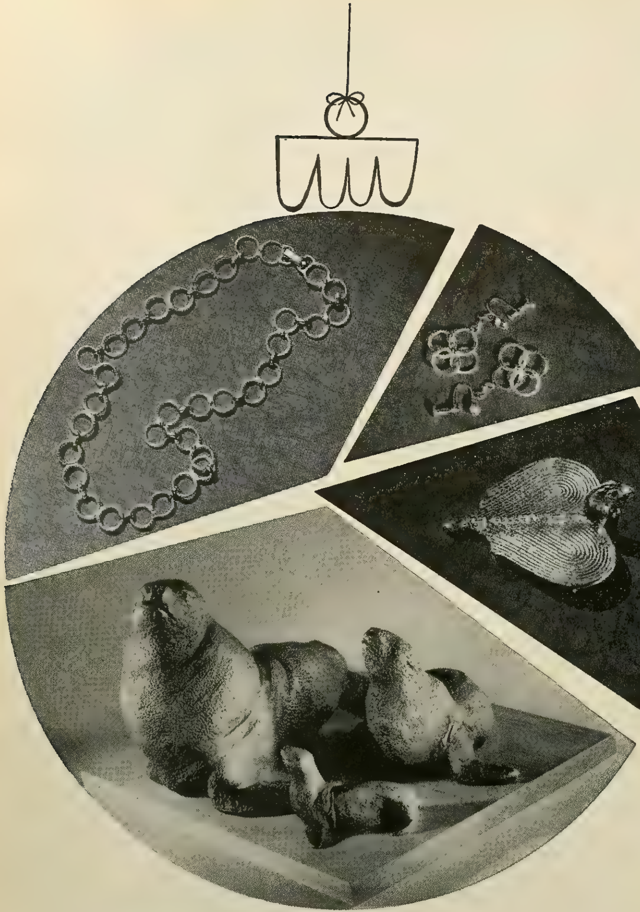
Miss Gandek attends Douglas College, and Dr. Pramer of Rutgers University is Professor of Agricultural Biology.



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# nature and photography

## taking movies of a home aquarium

### by Paul Villiard

PHOTOGRAPHING through glass is sometimes difficult. Photographing through glass and water together compounds the difficulty, and when you add subjects like exotic home aquarium fishes, actively swimming about, it can tax the patience and ingenuity of even experienced movie makers. With the aid of a few tricks and simple mechanical devices, however, one can easily obtain excellent motion pictures of these photogenic creatures.

There are several methods by which fishes can be confined to the somewhat limited dimension of the depth of field of a movie camera lens. A very narrow tank could be used, and, indeed, such tanks are frequently offered for sale for the purpose. Generally, though, they are deathtraps for the creatures put into them because of their extremely limited air-to-water surface area. The fishes quickly become distressed for air and often suffocate before the photographer—intent upon his work, or seeing them diminutively through the viewfinder—is aware that anything is wrong.

A better way of confining your subjects is to use a regularly proportioned aquarium, the largest size practical for your conditions, but certainly with no smaller capacity than five gallons. Two sheets of glass, as high as the inside of the tank and about 3 inches shorter than its length, can form a partition about 2 inches behind the tank's front glass. About 1½ inches of washed sand should first be placed in the tank. Then, the pieces of glass, their surfaces against each other, are embedded in the sand parallel to the front glass and slid apart horizontally to close off the area to be photographed. (It would be difficult to cut one sheet to exactly the size you need.) Planting should be done in the area behind this partition, with some of the plants close to the glass. This background will be out of focus—the desired effect—allowing the fishes themselves to be the center of interest. The plants will form a light-trapping background and act as a reflector to a certain degree, and the suggestion of wavy shapes will serve as a pleasing backdrop.

The camera should be mounted in front of the tank on a tripod or on some other steady support to eliminate vibration. (A telephoto lens is best. However, remember that vibration is amplified on the focal plane in direct proportion to the focal length of the lens.) Mark the photographic field on the front aquarium glass with a grease pencil. With four small marks just outside the field of lens vision, the subjects can be watched at all times and the best attitudes selected as they swim about, giving the photographer more time to prepare to work the shutter. A cardboard mask can also be used, with the size of the field cut out and the mask attached to the front of the tank. Masking has one great disadvantage, however; it shields the fishes from the photographer's view until they burst suddenly into the field.

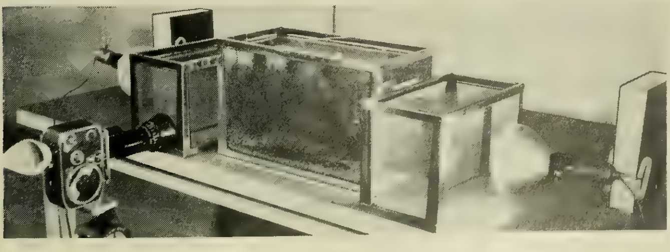
A few motion-picture cameras have a reflex device that allows the field to be viewed through the lens. With these cameras it is a simple matter to look through the lens and either guide an assistant in marking the glass or, if you can reach around the camera, to do it yourself. When using cameras equipped with viewfinders, parallax is a grave factor in the short distances involved, and such viewers cannot be depended upon to depict the field accurately. In this case, you must resort to the chart that gives the field dimensions for your particular lens at various distances. When these have been determined, you may use a wire field gauge, such as is available at larger camera supply stores, to guide you in marking the glass. You could also make one in a few minutes out of galvanized wire. If, for instance, the field at 18 inches is 8 inches high by 10 inches wide, a rectangle of these dimensions can be bent from a length of the wire and the ends fastened together with a piece of masking tape. An additional piece of wire is twisted around the frame at each corner and the ends brought together and fastened with tape. This will act as a pointer to center the frame accurately in relation to the position of the lens. The pointer wires should be an inch shorter than the depth of field—with an 18-inch field they should be 17 inches long—in order to place the plane of the subject a bit behind the front glass, since the fishes always swim somewhat away from the glass. The normal depth of field of the lens will take care of any discrepancy. With the wire device in place, you may now mark the field on the tank. (The device is, of course, then removed.)

In practice, each time the fishes swim within the defined margins of the field area you may work the shutter, and as long as they remain in position you may keep the camera going. It is not necessary to use the viewfinder. If you wish, you can center a floating ring feeder over the field area and drop a bit of food into it. As the food falls, the fishes will take it, and this will tend to keep them within the desired area and provide some action. A piece of window screen should be placed on top of the tank to keep the fishes from jumping out of the water. Ordinarily a sheet of glass would be used as a cover, but in a photographic arrangement there should be as much ventilation as possible.

## Lighting and Exposure

Lighting and its attendant bugbear—excess heat—are part of the same problem. If you are using black-and-white film, there are fast emulsions available that will give you good pictures under comparatively dim light. However, color film is much slower, and the lighting must be intense if you are to get full-spectrum movies. It is difficult to illuminate fishes from the front and, at the same time, to eliminate reflections. Most fishes do not exhibit their best colors under front lighting; side or top lighting is much to be preferred. Assuming that you have set up a five-gallon tank as your photographing area, a No. 2 photoflood lamp should be used close to each end of the tank.

Because two No. 2 photofloods would cook your subjects within a very short time, you must interpose a heat sink between the lamps and the tank. The simplest kind is a smaller aquarium—2½ or 3 gallon size—filled with water as cold as possible. The sinks will absorb most



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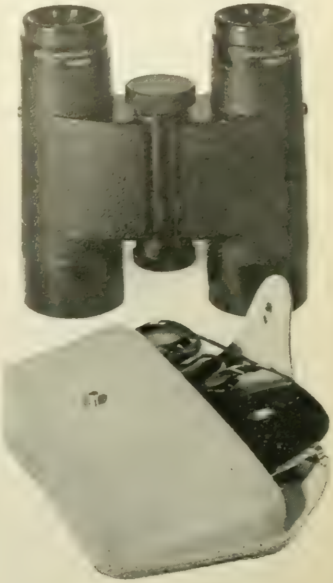

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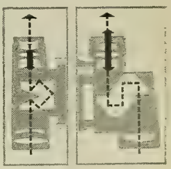

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PAUL VILLIARD, biophotographer and writer on many subjects in natural history, is also a "home aquarist."

of the heat from the lamps and keep the water in the main tank at a reasonable level during the picture taking. If you can obtain two sheets of heat-absorbing glass to interpose between the bulbs and the heat sinks, so much the better. If you are running long sequences during which the lights are kept on for extended periods, the water in the heat sinks can be changed from time to time, or ice cubes floated in them to lower the temperature. In any event, close watch should be kept on your main tank, and a thermometer should be suspended in the water out of range of the lens—and referred to frequently. The temperature should not go above 85° F. If you use ice to keep the water cool, cardboard should be placed in front of the heat sinks, or the ice, turning as it melts, may flash reflections into the lens.

Correct exposure is difficult to calculate in this kind of photography. The fishes are small and fleeting, and a meter reading is inaccurate at best. A reading might be obtained from the general illumination in the tank, but it is the fishes themselves in which we are interested. A good method is to run a test strip on black-and-white film of a faster speed rating, assuming, of course, that you intend taking movies in color. Select film with an ASA rating in exact, or close to exact, multiples of the ASA rating of your color film. For example, if the color film is rated ASA-10, try to get a test film rated about ASA-80. On this film run a few short sequences at different apertures, noting each aperture in the order taken. Develop the test strip, and note which sequence has the best exposure. The approximately correct exposure for your color film will be eight times that of the selected aperture on the black-and-white film in this example. The factor will change, of course, according to the ASA rating of the test film you select. The economy in this method is obvious.

An average motion-picture lens is calibrated at f/1.9, f/2.8, f/4, f/5.6, f/8, f/11, and f/16. Each stop is half or double the exposure of the stop preceding or following it—f/11 is twice the exposure of f/16. If in our hypothetical example the best exposure was at aperture f/11, we would multiply by eight. Thus, the diaphragm should be set at f/4 for color film. If you keep notes of the exposures, you may refer to them each time you make a setup, instead of taking the trouble of running many test strips.

Developing test strips of motion-picture footage is relatively easy. You are not interested in the quality or condition of the film, because you merely read the exposures and then discard the strips. If you do not have a darkroom, you may use any convenient closet large enough to accommodate an empty bucket, a clean pint or quart jar with a tight-fitting cover, a pair of scissors, a large bath towel or other cloth, a pint of made-up developer, a pint of fixer, and a timer you can preset.

With all this paraphernalia in the closet with you, close the door tightly and pack the towel on the floor against the bottom edge of the door to exclude all light. Open the camera and snip off the test strip. Unwind it from the take-up reel and stuff it, in loose snarls, into the jar. Try to keep the film from winding up tightly. Pour the developer into the jar and seal it. Start to count, or set the timer for the time designated on the package. Tip the jar end-over-end and rotate it during the development to insure complete saturation by the solution. At the end of the development time dump the developer into the bucket and pour the fixer into the jar, agitating as before. After a minute or two of fixing you may step out of the closet and complete the process in normal room light. Fix for about ten minutes more; then empty the jar and wash the film under cool running water for about five minutes. Hang the strip up to dry, which should take only a short time; then read the exposures. In all probability, the film will be scratched a bit from rough handling, but since this is a test strip, scratches don't really matter. Keep a record of aperture, shutter speed (frames per second), shutter opening if you have a variable shutter, and the ASA rating of the best section of test film. By doing this, it will be a simple matter to adjust the exposure up or down for faster or slower films at any time if all other working conditions are equal.

The procedures we have outlined in this discussion are relatively simple. They require neither expensive equipment nor knowledge of advanced photographic techniques. What they do call for are patience and care, which, if brought to bear as you follow the recommendations in this column, should result in home aquarium movies of excellent technical and aesthetic quality.

This list details the photographer, artist, or other source of illustrations, by page.

COVER—W. Gurnee Dyer
18-19—E. S. Higgs
20—top, W. T. Jones; bottom, AMNH after E. S. Higgs
21-25—E. S. Higgs
26-27—Celso Paulo Jaeger
28—Lick Observatory
29-30—Grumman Aircraft Engineering Corp.
31—AMNH
32-35—Robert Meyerriecks
36-39—W. Gurnee Dyer
40—T. C. Schneirla
41-42—AMNH
43-47—T. C. Schneirla except 47—right, AMNH; all diagrams, AMNH after T. C. Schneirla
48-49—Eddie L. Moore, U.S. Dept. of Agriculture
50-51—U. S. Geological Survey
52—Bryan T. Bannister
53-55—AMNH after U.S.G.S.
56-57—Irwin Dermer
58—"Soil Animals," McKevan
65—Paul Villiard

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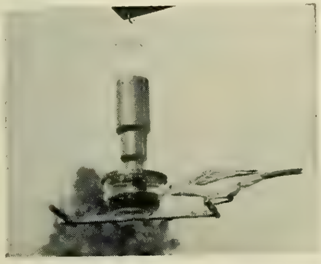

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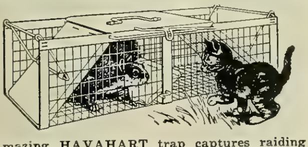

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The Climate, Environment and Industries of Stone Age Greece. Part I. S. I. Dakaris, E. S. Higgs, and R. W. Hey. *Proceedings of the Prehistoric Society*, Vol. 30. 1964.

Excavations at the Early Neolithic Site at Nea Nikomedeia, Greek Macedonia (1961 Season). R. J. Rodden. *Proceedings of the Prehistoric Society*, Vol. 28, 1962.

## GIANT SNAIL IS USED FOR MUSCLE STUDIES

Physiology of Mollusca. K. M. Wilbur and C. M. Yonge, Editors. Academic Press, N.Y., 1964.

## BROWN PELICAN IS VICTIM OF GULL PIRACY

Pirates and Predators. R. Meinertzhagen. Oliver & Boyd, London, 1959.

Social Feeding Behavior of Birds. A. L. Rand. *Fieldiana: Zoology*, Natural History Museum, Chicago, Vol. 36, No. 1, pages 1-71, 1954.

## GUELTA OF THE BLEAK SAHARA

From Libyan Sands to Chad. N. Heseltine. Museum Press, London, 1960.

La Civilisation Du Tchad. Jean-Paul Lebeuf and A. Masson Detourbet. Payot, Paris, 1950.

## DORYLINES: RAIDING AND IN BIVOUAC

Army-Ant Life and Behavior Under Dry-Season Conditions. T. C. Schneirla. *Bulletin of The American Museum of Natural History*, Vol. 94, pages 1-81, 1949.

Theoretical Consideration of Cyclic Processes in Doryline Ants. T. C. Schneirla. *Proceedings of the American Philosophical Society*, Vol. 101, pages 106-133, 1957.

Collective Activities and Social Patterns Among Insects. T. C. Schneirla. Chapter 28 in Insect Physiology, edited by K. D. Roeder. John Wiley & Sons, N.Y., 1953.

## REALITY OF DROUGHT IS ALWAYS WITH US

An Approach Toward a Rational Classification of Climate. C. W. Thornthwaite. *Geographical Review*, Vol. 38, pages 55-94, 1948.

Meteorological Drought. W. C. Palmer. *U.S. Weather Bureau Research Paper 65*, 1965.

Drought Climatology of Illinois. F. A. Huff and S. A. Changnon, Jr. *Illinois State Water Survey Bulletin 50*, 1963.

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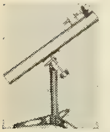


With this scope you can see the craters on the moon, the rings of Saturn, double stars. Mirror guaranteed to give theoretical limit of resolution. Rack-and-pinion focusing, removable mirror mount, counterweight. Real equatorial mounting. Aluminum tube, 6x finder telescope. Two standard-size eyepieces and our mounted Barlow lens gives you powers of 45x, 90x, 135x, 180x and 255x. f/11 mirror corrected to better than ¼ wavelength. Free with scope: Star Chart plus 272-page "Handbook of the Heavens" plus "How To Use Your Telescope." Shipping wt. 25 lbs.

**Stock #85, 105-E** ............ $79.50 f.o.b. Barrington, N. J.

Same telescope as described above but equipped with Electric Clock Drive.

**Stock #85, 107-E** . $109.00 f.o.b. Barrington, N. J.

**Superb 6" Reflector Telescope!** Includes electric **clock** drive, setting circles, equatorial mount, pedestal base, and four eyepieces.

**Stock #85,086-E** ......... ..... $199.50 f.o.b. Barrington, N. J.

## TINY LAMP GIVES SUN-LIKE BRILLIANCE FOR WORK, INSPECTION, EXAMINATION

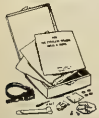
New, low-cost, miniature, high-intensity lamp gives concentrated daylight. Uses low-cost 12-volt auto bulb (GE 1133) yet gives light equivalent to 150-watt bulb, full 33 candlepower. Excellent all-purpose lamp for bench inspection of parts and assemblies, soldering, or as microscope light. Used as examination lamp by physicians and dentists, as work lamp by jewelers, technicians, artists, etc. Also attractive in any office or room, on desk, at bedside. 12" brass-finished gooseneck bends and holds to any position. No clamps or stands needed. Durable black metal trimmed in white. Base 4" dia. x 2½" high, has off-on switch, 5' cord. Reflector 2¾" dia. x 5½" long, white enameled inner surface.

**Stock No. 70,694-E** .... .. ... . $7.98 Ppd.

### Protect Glasses, Get Perfect Fit, Make Minor Repairs

## NEW EYEGLASS WEARER'S KIT HAS EVERYTHING

### For Home, Car, Office Work Areas



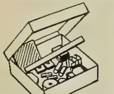
Here's a completely different gift—new, compact Kit of handy "solve-it-fix-it" items provides everything for comfort, protection, convenience. Get perfect fit, prevent breakage, loss, fogging; keep your glasses sparkling clean; make minor repairs on the spot! 10 item Kit contains: 3 Rubber Ear Pads; 9" x 8" Anti-Fog Cleaning Cloth; 2 Nose pads w/ adhesive backing; Adjustable Elastic Headband—fits glasses firmly, safely; attachable Wallholder; Jeweler's Screwdriver; 4 Replacement Self-locking Hinge Screws; 16" x 18" Silicon Treated, soft, reusable, Non-Woven Rayon Cloth for maximum cleaning efficiency; Rubber Hinge Rings to hold temple arms against head for snug, comfortable fit; Metal Clip for attaching case to sunvisor, etc. Incl. instr., test charts, eye-care hints.

**Stock No. 60,552-E** ........................ ........................ $5.00 Ppd.

### Explore the Fascinating World of Magnetism

## NEW 23 MAGNET VARIETY KIT

### 11 Shapes! Many Compositions!



Ever ripen tomatoes by magnetism—paint pictures using magnet as a brush and iron filings as paint? Surprising new ideas and uses for the bewildering forces of magnetism are continually discovered. Here, in one low-cost kit, you can learn and experiment with varied materials that obsoleted Magnetite—the natural magnetic ore. Terrific assortment includes ferrites, ceramics, flexible rubber, alnico in every shape imaginable up to 20 lbs. pull. Sizes range from ¾" x 7/16" x 7/16" x 3" x 3" x 1/32". Incl.: alnico w/hanlde. U-shaped alnico, three—2 sided ceramic, flexible strip, alnico bar, ceramic, alnico disc w/center hole, 2 lg. alnico cyl., sm. alnico cyl. flex sheet, 2 baby alnico bars, 3-channel-type pole pieces for sm. ceramic magnets, bar magnet keeper, 2 disc magnet keepers, compl. info. and inst. (Increase pull up to 5 times.)

**Stock No. 70,780-E** ...... ... ... . . . ..... ...... $5.00 Ppd.

**Order by Stock No.—Send Check or MONEY ORDER**
**Money-Back Guarantee**

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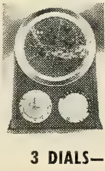
### AUTOMATICALLY SHOWS TIME, TIDES, POSITION OF SUN, MOON, STARS



## NEW SPILHAUS SPACE CLOCK

### 19 READINGS AT A GLANCE

### 3 DIALS—COMPLETELY ILLUMINATED

Startling scientific achievement, yet completely practical and functional. Designed for the space age by world renowned scientist, Dr. Athelstan Spilhaus, Dean of Technology, University of Minnesota. Handsome conversation piece—constantly up-to-date encyclopedia of the sky. The Spilhaus Space clock has beautiful fruitwood case and 3 illuminated sky-blue dials. Blends with decor of any home, office, club room, classroom, museum, display window, hotel, etc. Large dial shows sun position, daily sun rise and set, moon position, moon rise and set, phase of moon, low and high tide time, current stage of tide, day and month of year, current position of stars in sky, time of star rise and star set, relationships of sun, moon and stars, sidereal or star-time. Left dial shows local time. Right dial world time inlcuding major U. S. cities and Universal (Greenwich) time. Operates on house current—requires only one simple setting for any geographic location. Measures 16" high x 11½" wide x 4½" deep. Complete satisfaction guaranteed or money refunded. Shipping wt. 12 lbs.

**Stock No. 1202-E** ....................................................**$190. F.O.B.**

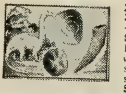
**SPECIAL 220-V., 50-CYCLE MOTOR—**
**illuminated dials**
**Stock No. 1203-E** ....................................................**$210. F.O.B.**

## HOME WEATHER STATION

New "Weather Station" is highly sensitive to weather changes. Consistently accurate thermometer to ± 2%; barometer accurate to ± .25" and hygrometer to ± 5%. Foretells weather changes from 12 to 24 hours in advance. Hygrometer calibrated in percent relative humidity. Excellent for teaching weather phenomena and meterological hobby work. Instrument mounted on handsome wood-grained wall panel 15½" x 5¾". Meter cases heavily metalized—combines beauty and protection. Dials, in etched aluminum, of high precision. Full instructions.

**Stock No. 70,607-E** ................................ ........ **$9.95 Postpaid**

## AGES-OLD FOSSIL COLLECTIONS



Millions of years old! 3 full sets—30 fantastic plant and animal fossils—all for $3.75. EARTH SCIENTIST SET: Dinosaur bone, crinoid stem, horn coral, worm tubes, petrified wood, bryozoa stem, lamp shell, scallop, sea urchin, oyster, clam, snail fossil. CARBONIFEROUS SET: Brachipod, worm burl, crinoid stem, fusuline, horn coral, bryozoan, snail and clam. CRETACEOUS SET: Brachipod, oyster, sea urchin, pertified wood, etc. All three sets for one low price!

**Stock No. 50,344-E** ................................... **$3.75 Postpaid**

### Revolutionary Technological Breakthrough in

## LIVING UNDER WATER

### Underwater Ant Nest Used to Dramatize Development

Sensational new development may be forerunner to underwater cities, the day man will live under the sea. Silicone Rubber Membrane enables ants (and other creatures) to live and breathe normally **by obtaining life giving oxygen from water** even though ant nest is submerged and sealed off completely from atmosphere. When ants consume oxygen in nest, pressure decreases below that of oxygen pressure in the water—allows oxygen from water (but not water) to pass through membrane. When carbon dioxide pressure increases inside nest it passes out through membrane. 3" x 5" membrane (.001" thickness) is bonded to dacron mat for mechanical strength and made exclusively, by hand craftsmen, for Edmund Scientific's experimental customers. Nest comes complete with sand, food, certificate to be returned for supply of ants. Complete instructions. Supply limited. Use your aquarium or order ours, listed below.

**Stock No. 70,801-E (Ant nest, membrane, instr.) $8.75 Ppd.**

**2½ GALLON PLASTIC AQUARIUM**
**Stock No. 90,014-E** ........................................................**$7.95 Ppd.**

## NEW BINOCULAR-TO-CAMERA HOLDER

### Will Fit Any Camera

**For Exciting Telephoto Pictures. Bring distant objects 7 times nearer with a 35mm camera. 7x50 binocular and** our NEW BINOCULAR-TO-CAMERA HOLDER. **Ideal for long-range shots of wild life, ships, people, vistas. Camera and binoculars attach easily.** Use any binocular or monocular—**any camera, still or movie. Take color or black and white. Attractive gray crinkle and bright chrome finish. 10" long. Full directions for taking telephotos included.**

**Stock No. 70.223-E** ............ ............................... **$11.50 Postpaid**

### Pistol Grip! Tripod! Window Mount! Wrist Strap!

## NEW SMALL BUT POWERFUL 10X TELESCOPE

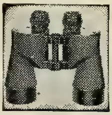
### Has Everything You Need!

Beautiful little instrument, 5" lg., fits hand perfectly, weighs only 7½ oz. Big objective lens—full 30mm diam.; prismatic; bright, right-side-up image. Perfect for vacationers, nature lovers, sportsmen, birdwatchers, etc. So compact, will fit in your pocket, ladies handbag, glove compartment, brief case, tackle box, etc. You're never without a rigid support—includes (1) 8" tripod (extends to 10", has rubber feet) with tilting-panning head; (2) pistol grip; (3) screw-in-wrist strap; (4) rubber padded car window mount. Threaded eyepiece for fast, smooth focusing from 20 ft. to infinity. 215-ft. field of view over 1000 yards. Coated objective and eyepiece. Fine, enamelled metal body, tan finish. 5¾" x 2" x 2" zippered, simulated leather case.

**Stock No. 70,775-E** ..................................................**$26.95 Ppd.**

### WAR SURPLUS! American-Made!

## 7x50 BINOCULARS



Big saving! Brand new! Crystal clear viewing — 7 power. Every optical element is coated. An excellent night glass — the size recommended for satellite viewing. Individual eye focus. Exit pupil 7 mm. Approx. field at 1,000 yds. is 376 ft. Carrying case included. American 7 x 50's normally cost **$274.50.** Our war surplus price saves you real money.

**Stock No. 1544-E**.....................................**only $74.80 pstpd.**

**7 x 35 AMERICAN MADE BINOCULARS**
**Stock No. 964-E** .................................................**$55.00 pstpd.**

**6 x 30 Binoculars**—Similar to above and a terrific bargain.
**Stock No. 963-E** .................................................**$40.00 pstpd.**

**Bargains Galore!** **Hours of Fun!** **Only $5**

## NEW POPULAR SCIENCE FUN CHEST

Here are Edmund's 9 top selling science toys and curiosities in one fascinating, low-cost package. Perfect gift item. Amuse and delight young and old for hours on end. Educational, too! Teach basic science principles in a wonderful new fun way. Incl.: **Solar Radiometer**—spins at 3,000 rpm; **Albert the Bobbing Bird**—runs continuously on thermal energy; Amazing **Sealed Mercury Puzzle**; Five 2-sided **Ceramic Magnets**: Big 3½" **Burning Glass** in Zip-Lip Poly Bag; **Magnetic Doggie and Spinning Ball**—ball spins as dog approaches; **Diffraction Grating Rainbow Viewer; PIK-UP Ring** (with Edmund TAK); Popular booklet, **"Astronomy and You."** All in die-cut storage box with complete instructions.

**Stock No. 70,787-E** ................................................ **$5.00 Ppd.**

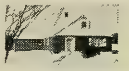
## NEW ZOOM TELESCOPE EYEPIECE

Exciting new eyepiece provides greater speed and versatility for your telescope. Does work of many and stays sharp at all powers. Magnification depends on your telescope—typically 50x to 120x. Precision construction, standard 1¼" O.D. Fully orthoscopic, coated lenses, focal lengths 8.4 mm. to 21 mm. Use of Barlow increases powers by 2 to 3 times with dramatic results.

**Stock #60,362-E**.......................................................**$26.50 ppd.**

### Build Actual Working Model

## NEW SOLAR HOUSE KIT



**Exact Replica of F.H.A. Approved Home**—Heat your house for $6 a year? The day may come. Four houses now heated by patented Solar Heat unit which harnesses the sun's rays. Investigate this new money-saving vital-energy prinicple and have fun for the whole family at the same time. All you need to harness the sun is this kit and a small supply of lumber, stone and insulating material. Complete house 19" x 16" x 15". Kit incl.: 2 thermometers, step-down transformer, fan, miniature motor, screen for heat collecting bin, plastic sheets, copper pipe, plastic tubing, electric water pump, water storage tank, pipe connections, metal reflector roof, assorted parts. Book, "Solar House Models" written by the inventor gives complete details.

**Stock No. 70,705-E** ... ..........................................**$24.50 Ppd.**

**ORDER BY STOCK NUMBER . SEND CHECK OR MONEY ORDER . SATISFACTION GUARANTEED!**

**EDMUND SCIENTIFIC CO., BARRINGTON, NEW JERSEY**

# for CHRISTMAS GIFTS!

## 'FISH' WITH A WAR SURPLUS GIANT MAGNET

### Bring Up Under-Water Treasures

Real fun! Profitable, too! Simply trail this powerful 5 lb. Magnet out the stern of your boat—retrieve outboard motors, fishing tackle, anchors, other metal valuables. Alnico V-Type Magnet has terrific lifting power- 2000 Gauss rating- lifts over 150 lbs. on land—more under water. Many industrial uses, too: recover tools and parts from inaccessible spots, hold work in place, rid shop floors of metal fragments, pins, etc.

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| **Stock No. 70,571-E** 5-lb. Magnet | $12.50 Pstpd. |
| **Stock No. 70,570-E** 3½-lb. Lifts 40 lb. | $ 8.75 Pstpd |
| **Stock No. 70,572-E** 7½-lb. Lifts 175 lb. | $18.75 Pstpd. |
| **Stock No. 85,152-E** 15¾-lb. Magnet Lifts 350 lbs. | $33.60 FOB |

## CRYSTAL GROWING KIT

Do a Crystallography project illustrated with large beautiful crystals you grow yourself. Kit includes the book "Crystals and Crystal Growing" and a generous supply of the chemicals you need to grow large display crystals of potassium aluminum sulfate (clear), potassium sulfate (purple), potassium sodium tartrate (clear), nickel sulfate hexahydrate (blue green) or heptahydrate (green), potassium ferricyanide (red), and copper acetate (blue green).

**Stock No. 70.336-E** — **$9.50 Postpaid**

## NEW! STATIC ELECTRICITY GENERATOR

### Sturdy, Improved Model

See a thrilling spark display as you set off a miniature bolt of lightning. Sturdily made—stands 14" high. Two 9" plastic discs rotate in opposite directions. Metal collector brushes pick up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping spark. 24 page illustrated booklet included.

**Order Stock No. 70,070-E** — **$12.95 Postpaid**

### Precision Marine Time Piece

## SHIP'S BELL CLOCK

### Faithful Time Afloat or Ashore

Handsome metal case in either brass or chrome. Highly corrosion resistant for use on shipboard or home. Finely made, unusually high quality. 8-day clock has familiar 1 to 12 dial—also marked with 24 hour system of timekeeping and traditional watch periods from Evening (or First) Watch through Second Dog Watch. Chimes nautical half-hour intervals from 1 to 8 bells (can be turned off). Thermometer at bottom of dial. Wt. 6 lbs.

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| **Stock No. 70,781-E** Brass | $60.00 Ppd. |
| **Stock No. 70,782-E** Chrome | $60.00 Ppd. |

## AN ART GALLERY IN YOUR OWN HOME 39 REMBRANDT ETCHINGS ON SLIDES

Some of the world's greatest art on black and white 35 mm slides. Study in detail the work of the greatest Dutch Master of all—biblical works, self portraits, family portraits, landscapes, still lifes. 39 etchings, plus 4 slides on etching techniques with keyed booklet of detailed descriptions. Plastic storage box.

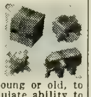
**Stock No. 60,522-E** — **$6.00 Ppd.**

## KNOW WIND SPEED ANYWHERE, ANYTIME WITH POCKET WIND METER

Useful to all outdoorsmen, especially sailors, shooters, fliers, golfers. Lightweight Pocket Wind Meter accurate to within 1 MPH. Two scales—low and high velocity. One from 2-10 MPH graduated in ½ MPH increments. Second from 10-66 MPH in 2 MPH increments. Easily read even in inclement weather. 6⅝" long x 1½" wide x ⅝" thick. Wt. approx. 2 ozs. Plastic pocket carrying case, instructions included.

**Stock No. 60.349-E** — **$4.95 Postpaid**

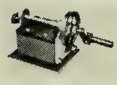
## WOODEN SOLID PUZZLES



12 Different puzzles that will stimulate your ability to think and reason. Here is a fascinating assortment of wood puzzles that will provide hours of pleasure. Twelve different puzzles, animals and geometric forms to take apart and reassemble, give a chance for all the family, young or old, to test skill, patience and, best of all, to stimulate ability to think and reason while having lots of fun. Order yours now.

**Stock No. 70,205-E** — **$3.00 Postpaid**

## WAR SURPLUS ELECTRIC GENERATOR



Brand new Signal Corps Electric Generator for scientific experiments, electrical uses, demonstrations. Generates up to 90 volts by turning crank. Use in high impedance relays. Charge ground and bring up night crawlers for bait or study. 2 Alnico Magnets alone worth original price. Wt. 2 lbs. Cost to Govt. $15.

**Stock No. 50.225-E** — **$6.95 Postpaid**

Same type generator, mounted, with light, as electricity demonstrator.

**Stock No. 50.365-E** — $11.95 Postpaid

## BE READY FOR THE MOON SHOTS

Ranger, Surveyor, Lunar Orbiter unmanned space probes will shed exciting new light on the mystery of the moon and outer space. See the results close up. Edmund low-cost, top quality equipment and accessories put you right there [illegible] provide valuable and complete information to keep you on target.

### See the Stars, Moon, Planets Close Up!

## 3" ASTRONOMICAL REFLECTING TELESCOPE

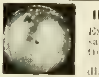
**Photographers!** Adapt your camera to this Scope for excellent Telephoto shots and fascinating photos of moon!

60 to 180 Power—**Famous Mt Palomar Type! An Unusual Buy!**

See the Rings of Saturn, the fascinating planet Mars, huge craters on the Moon, Phases of Venus. Equatorial mount with lock on both axes. Aluminized and over coated 3" diameter high speed f/10 mirror. Telescope comes equipped with a 60X eyepiece and a mounted Barlow Lens. Optical Finder Telescope included. Hardwood, portable tripod. FREE with Scope: Valuable STAR CHART plus 272 page "HANDBOOK OF HEAVENS" plus "HOW TO USE YOUR TELESCOPE" BOOK

**Stock No. 85.050-E** — **$29.95 Postpaid**

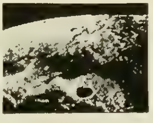
## INTRIGUING LOW-COST MOON MODEL



Exciting outer space display and conversation piece. Exact replica, 30,000 formations—peaks, craters, Ocean of Storms, etc. all in relief. Scaled to size. Accurate distance relationships. Proper lighting show moon phases; "black light" produces startling effects. Tough, washable plastic. Three colors. Far side blank—can be used for space data. Excellent gift item. 12" dia., wt. ¾ lb.

**Stock No. 70.515-E** — **$12.50 Postpaid**

## A SLIDE TRIP TO THE MOON—MOON TOPOGRAPHY STUDY AID



As the universe shrinks, interest in astronomy increases. This highly informative series of 29 black and white slides features such topography as the southwestern limb and Mare Imbrium—the "pearl" of the moon. Also, full moon taken with Mount Wilson 100-inch reflector and the crater Clavius through the 200 inch.

**Stock No. 60.348-E** — **$5.00 ppd.**

## ASTRONOMICAL HDQTS. U.S.A.

### Keep Pace with the Space Age

World's largest selection of telescopes and related equipment. Complete range of reflectors, refractors, panoramic, terrestrial, spotting, etc. Write for Free giant catalog "E".

### *New! 2 in 1 Combination! Pocket-Size*

## 50 POWER MICROSCOPE and 10 POWER TELESCOPE

Useful Telescope and Microscope combined in one amazing, precision instrument. Imported! No larger than a fountain pen. Telescope is 10 Power. Microscope magnifies 50 Times. Sharp focus at any range. Handy for sports, looking at small objects.

**Stock No. 30.059-E** — **$4.50 ppd**

## SCIENCE TREASURE CHESTS

**Science Treasure Chest**—extra powerful magnets, polarizing filters, compass, one-way mirror film, prisms, diffraction grating, and lots of other items for hundreds of thrilling experiments, plus a Ten Lens Kit for making telescopes, microscopes, etc. Full instructions

**Stock No. 70,342-E** — **$5.50 Pstpd.**

**Science Treasure Chest Deluxe**—Everything in Chest above plus exciting additional items for more advanced experiments, including crystal-growing kit, electric motor, molecular set, first-surface mirrors, and lots more.

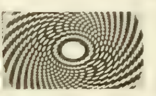
**Stock No. 70,343-E** — **$10.50 postpaid**

## BLACK LIGHT MAGIC-GLOW KIT

With this Kit, you can collect fluorescent rocks, paint with living light, write secret messages, learn invisible detection methods, even make a fluorescent Christmas tree! Kit uses long-wave blacklight, which is completely harmless to eyes, but causes fluorescence in over 3,000 substances. Includes Magic Glow Lamp, universal laboratory lamp stand, invisible water paints and ink, fluorescent crayon, tracer powder, pen, 3 brushes, specimens of fluorescent rocks: wernerite from Canada, fluorite from England, willemite from U.S.A. Plus book of 40 experiments.

**Stock No. 70-256-E** — $14.50 postpaid

## EXPLORE THE WORLD OF "OP ART"



### Fascinating New Experimenters'

## MOIRE PATTERNS KIT

### Fantastic Visual Effects! Limitless Applications

Now! Experiment with the amazing new tool of tomorrow. Basis of "OP ART" latest rage sweeping the country in art, fashion, packaging, advertising. Loads of uses for hobbyists, photographers, designers, lab and home experimenter. Fun! Profitable! Unlimited potential. Here your complete introduction kit developed by Dr. Gerald Oster, Brooklyn Poly. Inst. Contains 8 basic patterns on both clear acetate (lantern slide size [illegible]" x 4", [illegible] thick) and .012" thick white Kromekote paper [illegible]" x [illegible]" (coated one side), two pieces [illegible]" x 4" 150 dot screen on film. Copy Dr. Oster's book, "The Science of Moire Patterns", an authoritative introduction to the fascinating world of moire.

| | |
|---|---|
| **Stock No. 70,719-E** (KIT "A") | $8.50 Ppd. |
| **Stock No. 60,464-E** (without book) | $6.50 Ppd. |

## NOW AVAILABLE IN FULL COLORS

Wait 'til you see the fantastic rainbow of color—all 8 patterns above in full transparent colors, red, yellow and blue, plus black (total 40). Compl. instructions.

**Stock No. 60,530-E (Kit A)** — **$12.50 Ppd.**

## NEW DE LUXE EXPERIMENTERS' MOIRE KIT "B"

Eight new totally different black and white patterns: Coarse lines; 65-line sines; perspective squares; medium grating; Gaussian grating; converging circles; elliptical zone plate; 30-line logarithmic spiral; plus instructions by Dr. Oster.

**Stock No. 70,790-E** — **$6.00 Ppd.**

## NEW MOIRE KIT "B" IN COLOR

8 new patterns above in red, yellow and blue; plus black (total 40) with inst. by Dr. Oster.

**Stock No. 60,531-E** — **$12.50 Ppd.**

## NEW JUMBO 20" x 25" MOIRE PATTERNS

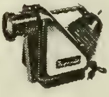
Excellent for displays and signs. Write for details and prices.

MOIRE PATTERN ACCESSORY KIT. For additional experiments. Incl. metallic balloon, calcite, two kinds of diffracting gratings, one-way mirror foil, polarizing materials, Ronchi rulings, assortments of lenses.

**Stock No. 60,487-E** — **$8.00 Ppd.**

### Terrific Buy! American Made!

## OPAQUE PROJECTOR



Projects illustrations up to 3" x 3½" and enlarges them to 35" x 30" if screen is 6½ ft. from projector; larger pictures if screen is further away. No film or negatives needed. Projects charts, diagrams, pictures, photos, lettering in full color or black-and-white. Operates on 115 volt, A.C. current. 6 ft. extension cord and plug included. Operates on 60 watt bulb, not included. Size 12" x 8" x 4½" W. 1 lb., 2 oz. Plastic case with built-in handle.

**Stock No. 70.199-E** — **$7.95 Postpaid**

## OPAQUE PROJECTOR WITH KALEIDOSCOPE ATTACHMENT

Same set as above, but provides endless additional projects with everchanging kaleidoscope patterns.

**Stock No. 70.714-E** — **$10.00 Ppd.**

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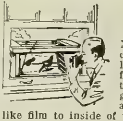

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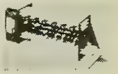

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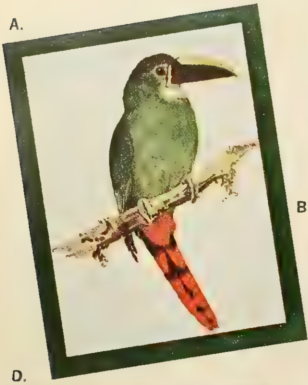

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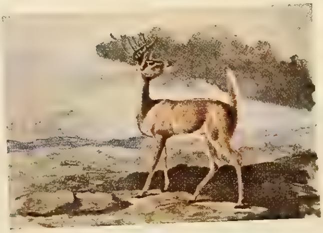

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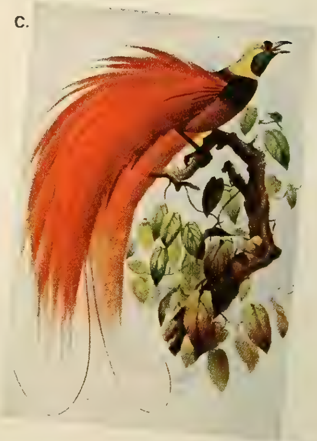

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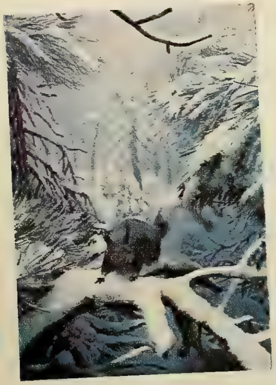

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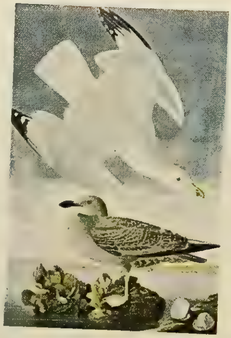

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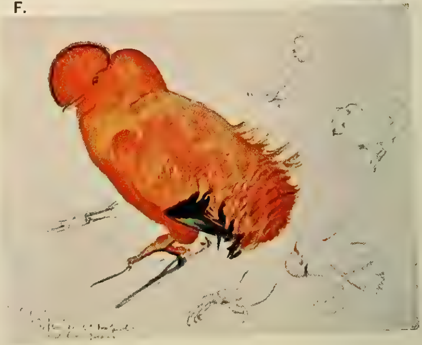

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*SEE—"The Illustrated London News", May 5, 1962, P. 699-701

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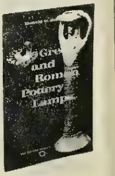

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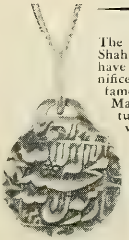

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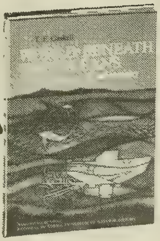

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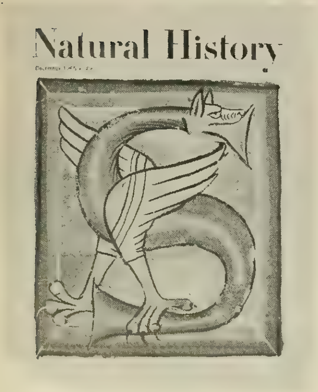

COVER: This example of an illuminated manuscript is from a south German psalter executed in the twelfth century. On pages 30-39, Shirley Alexander of New York University's Institute of Fine Arts explains the processes by which various metals were used to obtain both realistic and purely decorative effects. The methods of application and the metals themselves are discussed in relation to the manuscript's identity with certain schools of "illumination." All of the illustrations are from the Spencer Collection of the New York Public Library except for that on pages 34 and 35, now in the Walters Gallery in Baltimore.

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### BOOKS IN REVIEW

# Man's ecological crisis

### By William Vogt

CRISIS IN OUR CITIES, by Lewis Herber. *Prentice-Hall, Inc., $5.95; 239 pp., illus.* WITH EVERY BREATH YOU TAKE, by Howard R. Lewis. *Crown Publishers, Inc., $5.00; 322 pp., illus.* THE BREATH OF LIFE, by Donald E. Carr. *W. W. Norton & Co., Inc., $3.95; 175 pp.* CLEAN THE AIR!, by Alfred Lewis. *McGraw-Hill Book Co., $3.50; 96 pp., illus.*

THE human animal, compared with such species as the horseshoe crab or the cockroach, is a young and untried entity. Unlike most other creatures it has not adapted itself to the environment so much as it has adapted the environment to itself. It has carried sugar—and dental caries—to the Arctic and has built insupportable population densities in the tropics and subtropics, where it survives on a rather short-term basis by parasitizing and destroying the productive capacity of the land.

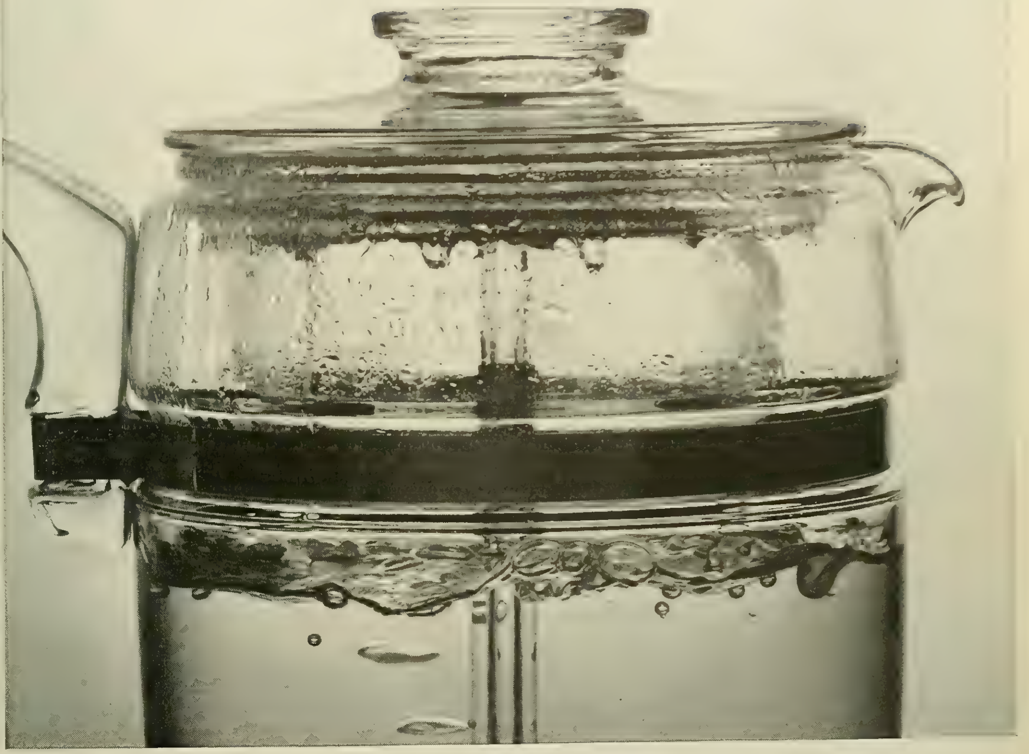
A few other animals—such as bees, some woodpeckers, and squirrels—store energy, but man is the only animal that can also transport it over thousands of miles. He has thus been able to leave behind him vast environments changed from the productive to the unproductive, whether of energy resources or of available and manageable water supplies. This is most notable in the Middle and Near East and in the tropics. Appalachia is a currently highly publicized North American area that has been robbed of much of its former capacity to grow food and fibers. Land once capable of providing for thousands of people has been degraded to third-rate watersheds. My own county in New York State (an extension of Appalachia) has a smaller population than it had in 1900, although national numbers have grown more than two and one-half times. Land that a few years ago supported prosperous farming now barely grows poor second growth. The ability to control our habitat is not an unmixed blessing.

Because of a favorable rainfall regime, northwestern Europe has been specially resistant to abuse, and the empirical land management methods slowly developed by a small population of peasants did a minimum of damage. Similar land-use methods transferred to the New World—often subject to torrential rainfall—wrecked part of it, but there fortunately remained the prairies and plains of our Midwest. The steppes of Patagonia, however, under overgrazing, are going the way of the steppes of Iran.

Twentieth-century man, who in terms of the species represents a mere 1/10,000 of its life span, has suddenly developed a new pattern of living that is based on such densities and sizes of populations as the species has never before encountered. He is exposing himself to hundreds of new chemical synthetics in the air he breathes, in the food he eats, and in the water he drinks. One of his measures of success is his ability to "produce" energy. Yet as two writers recently observed in *Science:* "Air pollutants are produced wherever energy conversion takes place under human direction."

As chronic bronchitis, lung cancer, and emphysema grow more prevalent, man seems to be choking to death on his own technology. He subjects his hearing organs to such unabating abuse as they have never known in the short life of the human race—to exacerbating ear pollution. He accepts, as normal, crutches for the eyes of a high proportion of civilized man, and even of his children. The human muscles that were evolved through hundreds of thousands of years of stern necessity and natural selection are as neglected as Greek idols. Stress, which is a normal demand on any organism, has been escalated until "nearly 10 per cent" of us need treatment in mental institutions; in one especially dense population studied, in a report that Lewis Herber cites, "four out of five people . . . had symptoms of psychiatric disorders. Roughly one out of four had neuroses sufficiently severe to disrupt their daily lives." The synergistic impacts of the processes of "civilization" are only beginning to be comprehended; they are the themes of these books.

Some of us are coming to recognize that we cannot remain healthy if we crowd ourselves together at the bottom of sumps in which natural meteorological processes concentrate poisons that have quite literally killed hundreds of people in a few days. The automobile, in extensive and crowded metropolises, exudes pathogens whose potential for evil is almost certainly only beginning to be appreciated. The town and city planner and the public health specialist of tomorrow will have to take a far more comprehensive and realistic view of human ecology than most of them yet dream of; and the costs of safeguarding human health, including the psyche, can no longer be put "on the cuff," no matter what they may do to conventional economic progress. Man's alteration of his environment has built an ecological monster that is turning on its creator.



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It is not many generations since Commodore Vanderbilt cried: "The public be damned!" and it is not surprising that big business—as individual corporations and trade associations—sets up the major obstacles against trying to clear the poisons from man's environment. Nothing must interfere with corporate profits! But as populations increase—a factor strangely underplayed by all four authors—and form bigger and bigger clots, radical prophylaxis must be devised and applied. Clearing our watercourses will, in itself, be an Augean task; the mere separation of storm and sanitary sewers may cost billions of dollars and an almost incalculable amount of inconvenience.

All four of these books can be heartily recommended, although Alfred Lewis' is little more than an illustrated hardcover pamphlet. Lewis Herber's well-documented book takes the broadest and most integrated approach to the whole human organism in its environment. He should be read by everyone who has any power to shape the destiny of the United States.

The other two titles are concerned solely with air pollution. Howard Lewis, a public health consultant, does a most thorough and authoritative job in this area; his documentation is impressive. Donald Carr, a journalist turned chemist and consultant, writes with wry humor and an almost burlesque perception of the way man has painted himself into a corner. While all four authors use many of the same sources, Carr is most skeptical of easy solutions. The usefulness of his book is much reduced by the lack of an index.

Four thousand people died from air pollution in less than a week in London in 1952, and another thousand in 1956. It is probable that only luck has averted a worse disaster here. Hundreds have certainly perished from the same cause in this country, with the source of the mortality unrecognized.

For hundreds of thousands of years man evolved in response to clean habitats that demanded certain physical reactions, including those of his nervous system. It is clear we cannot remain healthy in increasingly poisonous, stressful, and noisy environments, nor can we safely continue to ignore our hereditary behavior patterns.

Each of these books is as alive as tomorrow morning's headlines for the preponderance of Americans, and far more important than the day's news for most of us. It is unusual for a reviewer to be able to recommend a tetralogy of books with equal enthusiasm.

*Dr. Vogt, who is the Secretary of the Conservation Foundation, is a specialist in both human ecology and conservation.*

### THE PATHS OF CULTURE, by Kaj Birket-Smith. *University of Wisconsin Press. $10.00; 535 pp., illus.*

This is a vast, yet compact, history of human culture. It is written within the framework of thinking that characterized anthropology in the first decades of the twentieth century; the great sense of discovery, the rationalism, and the recognition that culture developed out of the continuing intercourse between peoples as they responded, on the one hand, to the challenge of the environment and, on the other hand, to the inventions of their neighbors. It also preserves the flavor of the fieldworker, whose experience with contemporary primitive peoples leads him to repudiate armchair mysticism about the prelogicality of primitive man and to assert vigorously the ability of the most primitive peoples to reason efficiently within the confining limits of lesser knowledge. Birket-Smith's field work among the Eskimos, and his inclusive knowledge of Danish archeology and Danish culture, give the book its particularity within the worldwide sweep he has attempted. The Chronological Chart, which covers the period 6000 B.C.—A.D. 1000 and traces the development of Denmark, England, Greece, Egypt, Mesopotamia, China, Mexico, and coastal Peru, gives the measure of this sweep.

Birket-Smith writes with authority, but he quotes no sources directly. However, under the various bibliographical headings, such as "Techniques," "Weapons and Hunting Implements," "Food and Stimulants," "Science," and "Culture Strata and Culture Waves," he provides selected references that demonstrate how well he has fitted later work —published as recently as 1962—into his early twentieth-century frame of thought. His discussions of technical problems are the most interesting. Occasionally, his enthusiastic discussion of multifaceted, overdetermined culture change is shot through with an abrupt dogmatism. He comments, for example, that in the study of the history of clothes "the *cut* is always decisive. On the whole, it is the cutter's art which enables us to follow the progress of history."

His treatment of religion and of social organization is ingenuous and disappointing. His repudiation of Freud is firmly based on views prevalent in the 1920's, and he makes no use of the modern work that places Lévy-Bruhl in a new context. He is not concerned with microcultural studies that involve human interaction. I know of no book in contemporary anthropology that so vividly preserves the humane spirit and the psychological and biological naïveté of the 1920's. Birket-Smith's general position is summed up in this statement on man's development: "Time and time again the history of culture shows that man's best qualities develop partly on the lowest stages, where life is simpler and there is less temptation to use violence than later on, and partly on the highest levels, where the consciousness of responsibility and justice has awakened. It is on the intermediary stages of culture that ideas run riot and excesses take place."

MARGARET MEAD
*The American Museum*

THE LONG DEATH, by Ralph K. Andrist. *The Macmillan Co., $8.95; 371 pp., illus.*

RALPH ANDRIST writes about the Indian wars on the Great Plains from 1860 to 1890. During these three decades, the tribes of the plains were militarily defeated by the United States, stripped of most of their land, and placed on relatively small reservations. Confinement on reservations marked the beginning of a period of rapid cultural breakdown. Today, all but a few remnants of aboriginal Plains Indian culture have vanished, although there are more Plains Indians living today than there were in 1860 when their culture was on the threshold of what Andrist calls *The Long Death.*

Primarily the author describes military events and the political negotiations accompanying them. An introductory chapter gives a general review of United States policy toward the Indians in the middle of the nineteenth century. The following eight chapters deal with the better-known battles—in chronological order—from the Sioux outbreak in Minnesota in 1862 to the massacre at Wounded Knee in 1890. Most of the engagements were on the plains, but Andrist could not resist including two of the most famous wars from farther west: the remarkable 1,300-mile retreat of the Nez Percé, which ended in their capture only 30 miles from safety in Canada; and the Modoc War, in which fifty Modoc warriors withstood for six months an army of the United States that numbered about 1,000 men during the last three months of the engagement.

It is easy to see why the Plains Indian wars have captured the imagination of Americans. The enemy was courageous and colorful (but posed no real threat), the field of action was vast and beautiful, and the picture of cavalry units riding from frontier forts behind flapping guidons recalls a simpler era when war was a game full of excitement and gallantry and difficult problems could be solved by brief, decisive military action.

But there is another reason for our fascination with the Indian wars. A close examination of their causes, conduct, and aftermath gives us an insight into our own morality. The picture is not reassuring. Andrist analyzes in some detail the negotiation of treaties between the United States and the Indians, their violation by the United States, the negotiation of new treaties, *their* violation, and so on. He provides little comfort for those who like to think that the Indians gave or sold their land freely and that the United States never took it by force. The Indians usually consented, but only after they had been placed under considerable pressure. The normal sequence of events was a gradual encroachment on Indian lands by whites, then clashes, then a cry from the settlers for army protection. The army defeated the Indians, and a treaty was signed in which the Indians surrendered part of their land, but the remainder (or new land) was to be theirs "as long as the waters run and the grass shall grow." Soon the ceded land filled up, settlers again moved into Indian country, and the cycle was repeated. The morality underlying these actions was simple: few Americans felt that the Indians had any rights whatsoever. The United States Government was unwilling or unable to meet the obligations of its own treaties. While Andrist generally places most of the blame for hostilities on the United States, he does not hesitate to censure the Indians when they deserve it—as in the case of the senseless massacre perpetrated by the Sioux in Minnesota.

This is an interesting book that is a pleasure to read. The author's descriptions of the various battles are clear and exciting. Excellent maps accompany each chapter and make the action easy to follow. The book is further illustrated with photographs.

STANLEY A. FREED
*The American Museum*

MERIWETHER LEWIS, by Richard Dillon. *Coward-McCann, Inc., $6.95; 364 pp., illus.*

IN reading Richard Dillon's *Meriwether Lewis,* I was surprised and pleased to find that it contains information not included in other recent books on the Lewis and Clark expedition, concerning Lewis' life prior to, and following, the tour of discovery. It is obvious that Mr. Dillon did a great deal of painstaking research, and he is to be congratulated on his ability to select, organize, and present the facts—gleaned from many sources— in a lucid, interesting manner.

The first seven chapters of the book deal with Lewis' early life, his army career, his experiences while serving as President Jefferson's private secretary, and his activities in preparation for his historic journey from St. Louis to the mouth of the Columbia River. In these early chapters, a good deal of new mater-

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ial is presented. For example, there is an explanation of Jefferson's efforts to conceal the real objectives of the expedition from his critics in Washington and from the Spanish who, before the Louisiana Purchase, ruled the vast area drained by the Missouri River. Also, the actual cost of the expedition, including supplies and materials obtained from army stores, is listed at $38,722.25 rather than the $2,500.00 that was originally appropriated by Congress. There is a detailed description of Lewis' difficulties in descending the Ohio River in the heavily loaded, sixty-foot keelboat that was launched at Pittsburgh on August 31, 1803. Lewis' adroit negotiations with the Spanish officials in St. Louis during the winter of 1803-4 are emphasized.

Chapters VIII through XIX recount Lewis and Clark's observations and experiences as recorded in their diaries during the period of exploration, but nothing unusual is added.

On the other hand, in the last three chapters of his book, Mr. Dillon gives us new insight into Lewis' character, his difficulties during the brief period in which he served as Governor of Louisiana, and the peculiar circumstances relating to his suicide or murder on October 11, 1809, at Grinder's Stand on the Natchez Trace in Tennessee. We are led to conclude that his difficulties in governing the Territory stemmed in part from the attempts of Frederick Bates, whom Jefferson had made Secretary of Louisiana, to discredit the Governor with his superiors in Washington and with the public in general.

These concluding chapters alone make the book worth reading.

R. D. Burroughs
*Willamette University*

Museums, U.S.A., by Herbert and Marjorie Katz. *Doubleday & Co., $6.50; 395 pp., illus.*

Museums are in the news these days. Old, established institutions expand, new buildings arise to house hitherto obscure collections, and public interest increases day by day. No wonder there have recently been several books on the subject.

The latest and most comprehensive work about the American museum scene is *Museums, U.S.A.* by Herbert and Marjorie Katz. Subtitled "A History and a Guide," it does, indeed, try to be both, but runs into considerable difficulty in reconciling these two different functions. The first 266 pages can be described as the historical section, in which—after a general background chapter—there are five arbitrary but sensible divisions: "Art," "Science," "History," "Children," and "An Infinite Variety." The individual histories of major museums, although superficial, are certainly readable and should whet the appetite of serious readers to turn to more detailed descriptions. The excellent bibliographic notes make such reference easy. However, some of the histories contain inaccurate references to current museum exhibits and activities. For example, a visitor asking to see The American Museum of Natural History's Hall of Ocean Life, which is described as one of the museum's well-lit, brand-new displays, would have to be told to come back in two years, by which time the exhibits will be built.

A 110-page Appendix follows this section, and consists of a listing of more than 2,500 museums by state and city, with brief notes on their collections. Many of these notes are so abbreviated that they leave the reader in doubt as to the nature of a museum's exhibits. The listings for major museums can, of course, be read in conjunction with the histories to provide a more rounded picture, but this provides, in some cases, only selective information. The 40 black-and-white and halftone illustrations are neither well chosen nor attractively laid out.

The book, therefore, can best be described as a general introduction to the origin, development, and scope of American museums today, somewhat heavy on anecdote, but written with genuine knowledge of, and enthusiasm for, the subject. No other single publication covers so broad a field, so its usefulness, despite its limitations, is evident.

Gordon Reekie
*The American Museum*

The Birds of the Palearctic Fauna: Non Passeriformes, by Charles Vaurie. *H. F. & G. Witherby, Ltd., London, approx. $20.00; 763 pp.*

This is a scholarly book written by an ornithologist for ornithologists. However, like other such standard works, its influence will go far beyond the ornithologists and zoogeographers who will keep it on their bookshelves as a reference tool. True, few of the multitude of bird watchers with popular handbooks and guides, and few of those who look up information about birds in encyclopedias and dictionaries consult volumes such as Vaurie's—the primary sources and the solid support for scientists and writers.

In this volume, and in the author's companion volume, *The Birds of the Palearctic Fauna: Order Passeriformes,* published in 1959, we have an authoritative, systematic list of the birds that breed in the Palearctic region—the area that extends from Greenland across Eurasia to the Bering Sea, and south to North Africa, the Himalayas, and Japan.

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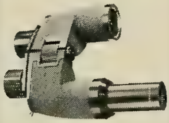

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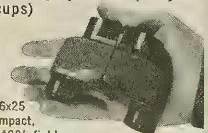

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North America—the Nearctic region—shares many of its birds with the Palearctic, especially those of the tundra and the northern coniferous forests. Hence, the students of North American birds will find Dr. Vaurie's volumes excellent shelf companions for the *Check-list of North American Birds*, prepared by the American Ornithologists' Union. Although data in these publications show minor differences in arrangement and names, these present no real difficulties.

Each book has its strong points. The A.O.U. *Check-list* lists breeding birds, migrants, strays, and accidentals, each with an equal amount of data. Vaurie's *Birds* gives full treatment to breeding birds only, and dismisses migrants and strays with sparse, summary comment. For the breeding birds, the book gives not only name, original citation, and range—as does the A.O.U. *Check-list*—but also recent synonyms, discussions of relationship where appropriate, subspecies diagnoses, and habitats. For far-ranging species the extralimital subspecies are presented in synoptic form. One has the impression that the A.O.U. work is a more finished, formal listing, perhaps containing more of interest to bird watchers looking for unusual records. Vaurie's *Birds*, with its greater amount of information, will be of greater interest to students of speciation, zoogeography, and ecology. We can hope the next edition of the A.O.U. *Check-list* will incorporate these desirable features of Vaurie's work.

A. L. Rand
*Chicago Natural History Museum*

### From Cave to Cathedral, by E. O. James. *Frederick A. Praeger, $12.50; 404 pp., illus.*

The aim of this historical and archaeological investigation of the structure, function and significance of sacred places is to bring together their material and spiritual aspects . . . relating the . . . visible manifestations to their . . . spiritual purposes in the religious milieu in which they emerged." Here, then, are chronicled the holy places that served early man so that he could better serve his gods. Beginning in the dark sanctuaries of the Late Pleistocene caves, the reader is carried on a synoptic tour of ancient shrines, temples, and churches in the Near East, Egypt, India, Greece, and Rome. The order of the tour is determined by geography, chronology, and religious group.

Every author beginning a book has a more or less clear idea as to why his projected labor is useful. E. O. James, Professor Emeritus of History of Religion at the University of London, with more than a dozen books to his credit, is no exception: he wants to bring to the reader "a full understanding of the religious purposes and functions of sacred places." To achieve this end, he develops a three-part plan. First, he briefly defines the spiritual and physical milieu of the cult or religion. Second—and this part forms the bulk of the volume—he describes the architecture and equipment of the shrines. And, third, he highlights pertinent aspects of each religion. An experienced teacher and writer, he follows this pattern of organization with clarity, precision, and authority.

Yet the volume is somewhat curious, if not dissatisfying, perhaps because the reader misses a hoped for fourth ingredient—a synthesis drawn from a plethora of detail. In the main, the work is descriptive, detailing the measurements, plans, materials, and construction of building after building. Such verbal descriptions are apt to become confusing and tedious unless they are reinforced by detailed photographs, drawings, and diagrams. While the book is pleasantly illustrated, the figures are insufficient to the task, and are not referred to by number in the text. One waits in vain for summaries, extrapolations from the accumulated evidence, that would bring meaning to the listing of details. The significance of a temple, after all, does not lie in its linear footage, thickness of walls, nor composition of roof tiles, unless the author deduces, from the architectural data, the consequence of the shrine, which he uses to explain the social, spiritual, and psychical climate of the community that produced it.

The volume reads somewhat like a compilation of note cards that does not achieve the aim the author set himself. Although it is difficult to read at one go, it does serve as an admirable short-reference encyclopedia of major ancient religious architecture, or rather, it might have, had the index been made complete. Critical material discussed in the text—Diktean Cave, vihara, labyrinth, stone alignments—is omitted. The vast scope of the author's learning is clearly evident, but one prefers his splendid, earlier study (1957) in the same area: *Prehistoric Religion, A Study in Prehistoric Archaeology*.

Bernard Goldman
*Wayne State University*

### Deadly Harvest: A Guide to Common Poisonous Plants, by John M. Kingsbury. *Holt, Rinehart & Winston, Inc., $4.50; 127 pp., illus.*

Although we are aware of the presence of poisonous plants, few of us have had firsthand experience with more than poison ivy or poison oak. In reality, it is not an exaggeration to say that we expose ourselves to plant poison daily, not only on picnics or on strolls through the country but also at home or even at the supermarket. The popular house plants *Poinsettia* and *Dieffen-*

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*bachia*, for instance, are poisonous, and pretty red-and-black precatory beans are sold at souvenir stores without warnings of their extreme toxicity.

*Deadly Harvest*, by John M. Kingsbury, a concise edition of his elaborate work *Poisonous Plants of the United States and Canada* (1964), is a nontechnical handbook to which the layman may go for basic information about the poisonous plants of the United States and Canada that he may encounter in the course of everyday affairs. This commendable small volume tells the reader the kinds of common poisonous plants; how they become involved in our lives; what their poisonous elements are; how we react to the poisons; and how to avoid contact with these pernicious species.

Chapter 1 is an introduction to familiar poisonous plants. In Chapter 2, the author skillfully and engagingly gives the history of many uses of plant poisons—arrow poison used by primitive people; the poisons administered by physicians of ancient times; murder by plant poison in past centuries; and recent developments with plant poisons in this country, including ergotism. Chapter 3 is more technical, for here poisonous plants are explained taxonomically, with morphological indications of which parts contain the dangerous elements. Chapter 4 gives the biochemical interpretations of poisonous plants, and Chapter 5 warns against extremely poisonous ones, such as the sometimes-cultivated monkshood, or common wild plants, including pokeweed, horse-chestnut, and elderberry. In the final chapter, the author gives precautions and directions to follow in the event of an emergency.

Despite its modest size, *Deadly Harvest* is remarkably comprehensive. The copious illustrations, accompanied by brief descriptions of the plants, are particularly useful as an aid in primary differentiation. Although its subject is a province of science, this book offers enjoyable and interesting reading. I feel every home should have a copy of the work, kept—like a cookbook or a first-aid manual—especially accessible to mothers, whose knowledgeable action may prevent possible tragedy.

TETSUO KOYAMA
*The New York Botanical Garden*

### THE AGE OF REPTILES, by Edwin H. Colbert. *W. W. Norton & Co., Inc., $8.50; 228 pp., illus.*

For a period that lasted nearly two hundred million years the lands of the earth were populated by an almost unbelievably varied array of reptiles. Some of their relatives had invaded the seas, adapted to an aquatic mode of life, and had become almost as successful. There were, in addition, flying reptiles at home in the air. Less than one hundred million years ago the peak of reptilian radiation was reached, and a decline set in, culminating at length in a great extinction. Snakes, lizards, crocodiles, turtles, and the tuatara are remnants that have survived to the present time. The story of the origin and rise, the successes and failures, and the final decline of reptiles is told in an easy and interesting style by Dr. Edwin H. Colbert, one of the top authorities in the field today.

The earliest reptiles were but little different from their amphibian ancestors —in fact there is much dispute as to where some of them are to be placed in formal classification. Like the amphibians, they dwelt close to the water, partially tied to this medium by both their structure and their life habits. The first reptiles to become numerous and varied in form and function were the synapsids, often called the mammal-like reptiles. They flourished in the Late Paleozoic and Early Mesozoic Eras of earth history and were the progenitors of the mammals. About two hundred and fifty million years ago, during the Triassic Period of the Early Mesozoic, replacement of the mammal-like reptiles by others that were to dominate the scene during the rest of the Mesozoic began. Best-known among these newcomers are the dinosaurs. Discussions of the evolution, history, geographic distribution, and ways of life of the dinosaurs, the marine reptiles, the flying reptiles, and a host of less spectacular relatives form the heart of the book. The way they occur as fossils and the problems of interpreting a long-past, fragmentary history are kept constantly in the foreground.

*The Age of Reptiles* was written for a general audience. For the most part, it attains its goal of presenting an authentic and readable account of reptilian history. It is not, however, entirely easy going. Most chapters begin in a conversational mood, but they tend to become moderately technical as they develop. Careful reading is required. Excellent illustrations of the important animals, and charts and graphs of geographic and temporal distributions of the fossils are well designed to help the reader. A first-rate, annotated reference list points the way to additional study in areas that may prove of special interest to the reader.

The final chapter, dealing with the extinction at the end of the Mesozoic Era, is the most interesting and challenging. All of the earlier chapters point toward this as yet unexplained event. The author makes no pretense of providing definitive answers, but points out clearly the trends that led toward the mass extinctions, and nicely counters the many simple and naïve solutions that have been put forth.

The expert can find technical points to criticize. Some aspects of the classification are extremely conservative, and forms that are not closely related are grouped together. The use of Cotylosauria is a case in point. But all such objections are minor and of little importance in the book as a whole. *The Age of Reptiles* is interesting and stimulating, and will reward the careful reader with many pleasant hours.

EVERETT C. OLSON
*University of Chicago*

### GENETICS AND THE SOCIAL BEHAVIOR OF THE DOG, by John Paul Scott and John L. Fuller. *The University of Chicago Press, $12.50; 468 pp., illus.*

In the preface of this volume, the authors indicate that the book "should be of interest to dog owners and breeders as well as theoretical scientists." It is to their credit that they have managed to produce a work of interest to such a diverse audience. The breadth of material covered is vast, ranging from the origin of dogs, through the genetics of morphological and behavioral breed characteristics, to speculative comparisons of canine and human evolution. Most of the experimental data are drawn from extensive studies carried out over a thirteen-year period at The Jackson Laboratory, Bar Harbor, Maine.

Mention is made in both the preface and the text of the importance of the ethological work of Lorenz and Tinbergen; however, I was surprised to find no reference to the extensive observations on canine behavior made by Lorenz. In his book *Man Meets Dog*, Lorenz presents considerable behavioral evidence for a dual origin of domestic dogs; some dogs originating from a jackal ancestry and others from a wolf ancestry. Scott and Fuller, on the other hand, conclude that all domestic dogs have originated from a wolf ancestry and never mention Lorenz' data or conclusions on this subject. If Lorenz' hypothesis is true, one would expect that wolves and jackals can interbreed and produce fertile offspring. Unfortunately, this information does not seem to be available.

The behavioral comparisons made between dog breeds and human races, and between individual variation in both dogs and men are interesting; they may provide a new method for deeper understanding of our own evolutionary past and present, especially in regard to juvenile behavior, since the studies centered on young dogs. To the non-professional reader, however, these comparisons may also reinforce the too-prevalent anthropomorphism of canine behavior.

DOUGLAS B. WEBSTER
*New York University*

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# Territorial Needs and

### By Edward T. Hall

TERRITORIALITY is usually defined as the behavior by which an organism characteristically lays claim to an area and defends it against members of its own species. This concept is a recent one, but territorial studies are already revising many of our basic ideas of animal life and of man as well. The expression "free as a bird" is an encapsulated form of our belief in man's relation to nature. Animals are seen as free to roam the world, while man is imprisoned by his culture. Studies of territoriality show that the reverse is closer to the truth and that animals are often imprisoned in their own territories.

H. Hediger, Zurich's famous animal psychologist, says that territoriality insures the propagation of the species by regulating density. It provides a frame in which things are done—places to learn, places to play, safe places to hide. Thus it co-ordinates the activities of the group and holds the group together. It keeps animals within communicating distance of each other, so that the presence of food or an enemy can be signaled. An animal with a territory of its own can develop an inventory of reflex responses to ter-

# Limits

**Walruses** are among the social animals that must have close physical contacts.

**Individuals** of species will usually keep uniform distance between each other.

rain features. When danger strikes, the animal on its home ground can take advantage of automatic responses; it does not need to "think."

Differences in territoriality have become so widely recognized that they are used as a basis for distinguishing between species, much as anatomical features are used. Territoriality offers protection from predators, and also exposes to predation the unfit that are too weak to establish and defend a territory. Thus it reinforces dominance in selective breeding. Territoriality facilitates and possibly insures breeding by providing a home base that is safe. It aids in protecting the nests and the young in them. In some species, it localizes waste disposal and inhibits or prevents parasites. Yet one of the most important functions of territoriality is to protect against overexploitation that part of the environment on which a species depends for its living.

Man, too, has his territory, and he has invented many ways of defending it. To remove boundary markers and trespass upon the property of another man are punishable acts in the Western world. A man's home has been his castle in English common law for centuries. Distinction is carefully made between private property, which is the territory of an individual, and public property, which is the territory of the group.

Basic to territoriality, and to many other functions of space in the animal world, is a sharp sense of the limits that mark the distance to be maintained between individuals. Hediger has identified a series of distances that appear to be used in one form or another by most animals. Two of these—flight distance and critical distance—are used when individuals of different species meet; the two others—personal distance and social distance—occur during interactions between members of the same species.

Any observant person has noticed that a wild animal will allow a man or other potential enemy to approach only up to a given distance before it flees. "Flight distance" is Hediger's term for this interspecies spacing mechanism. As a general rule, there is a positive correlation between the size of an animal and its flight distance. The larger the animal, the greater the distance it must keep between itself and the enemy. An antelope will flee when the intruder is as much as five hundred yards away. The wall lizard's flight distance is about six feet. The flight reaction is one of the basic mechanisms of survival. There are, of course, other ways of avoiding a predator, such as camouflage, protective armor or spines, or offensive odor. But flight is for mobile creatures. In zoos, it is essential to modify the flight reaction enough so the captive animal can move about, sleep, and eat without being panicked by man, his natural enemy.

In spite of the fact that man is a self-domesticated animal, the domestication process is only partial. We see this in certain types of schizophrenics who experience something very similar to the flight reaction. When approached too closely, schizophrenics panic in much the same way as an animal recently locked up in a zoo. In describing his feelings, the schizophrenic is likely to refer to anything that happens within his flight distance as taking place literally inside himself. This indicates that the realization of the self, as we know it, is intimately associated with the process of making boundaries explicit.

Critical distances or zones apparently are present wherever and whenever there is a flight reaction. "Critical distance" encompasses the narrow zone that separates flight distance from attack distance. A lion in a zoo will flee from an approaching man until it meets an insurmountable barrier. If the man continues the approach, he penetrates the lion's critical distance; then the cornered lion reverses direction and begins slowly to stalk the man.

In the classical animal act in the circus, the lion's stalk is so deliberate that he will surmount an intervening obstacle such as a stool in order to reach the man. To get the lion to remain on the stool, the lion tamer quickly steps out of the critical zone. At this point, the lion stops pursuing. The trainer's elaborate "protective" devices—the chair, the whip, or the gun—are so much window dressing. Hediger says the critical distance for an animal is so precise that it can be measured in centimeters.

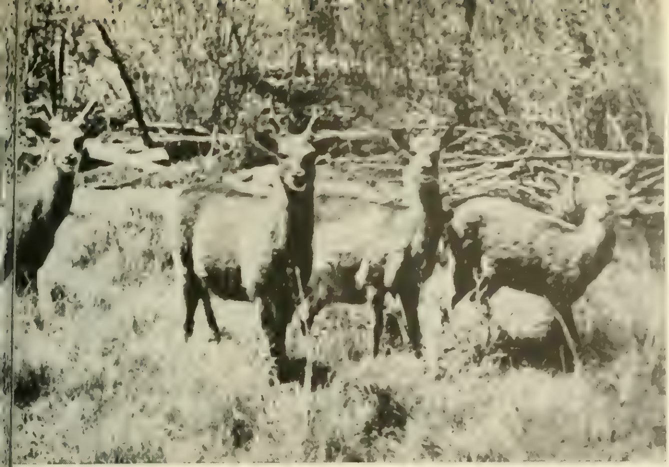
Regarding the use of space, it is possible to observe a basic and sometimes inexplicable dichotomy in the animal world. Some species require physical contact, while others completely avoid touching. No apparent logic governs the category into which a species falls. Contact creatures include the walrus, the hippopotamus, the pig, the brown bat, the parakeets, and the hedgehogs, among many others. The horse, the dog, the cat, the rat, the muskrat, the hawk, and the black-headed gull are non-contact species. Curiously enough, closely related animals may belong to different categories. According to Basel's zoo director, Professor Adolf Portman, the great Emperor Penguin is a contact species. It conserves heat by huddling in a large group and thus increases its adaptability to cold. Its range extends over many parts of Antarctica. The smaller Adélie Penguin is a non-contact species, and its range is apparently more limited.

It is clear that all warm-blooded animals begin life in the contact phase. This phase is only temporary with the many non-contact species, for the young abandon it as soon as they leave their parents and are on their own. From this point in the life cycle of both types, regular spacing between individuals can be observed. Hediger calls such spacing "personal distance." There is some indication that personal distance may be an internalized version of territory.

At this point, the main concern for us is the fact that dominant animals tend to have larger personal distances than those which occupy lower positions in the social hierarchy. Personal distance undoubtedly contributes to the regulation of aggression. Such regulation is a major objective of social organization. A strong, aggressive animal can eliminate weaker rivals. Aggression enhances the elaboration of display behavior, and in this way, too, it serves as a handmaiden in the process of natural selection. However, to insure survival of the species, aggression must be regulated. This can be done in two ways: by development of hierarchies and by spacing. Ethologists seem to agree that spacing is the more primitive method because it is both the simplest and the least flexible.

Social animals must stay in touch with each other, for loss of contact with the group can be fatal for a variety of reasons, including exposure to predators. Social distance is not simply the distance at which an animal can no longer see, hear, or smell the group. Rather, it is a psychological distance—one at which the animal apparently begins to feel threatened if the limits are exceeded.

Social distance is not always rigidly fixed, but is determined in part by the situation, in part by the species. When the young of apes and humans are mobile but not yet under control of



SIKA DEER study on a Maryland island provided data on overcrowding effects.

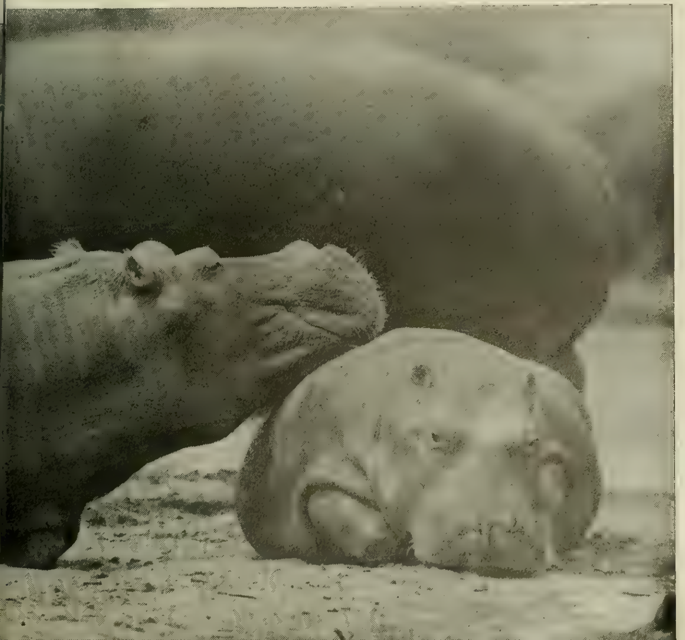
the mother's voice, social distance may be the length of her reach. This is readily observed among baboons in a zoo. When the baby approaches a certain point, the mother reaches out to seize the end of its tail and pull it back to her. When added control is needed because of danger, social distance shrinks. To document this in man, one has only to watch a family with a number of small children holding hands as they cross a busy street.

ANOTHER aspect of space relations can be found in "critical space" and a "critical situation," examples of which may be seen in the North Sea crab, *Hyas araneus*. Periodically, when the crab sheds its shell, its only protection is the space that separates it from crabs in the hard-shell stage. Once a hard-shelled crab gets close enough to scent its soft-shelled fellow—that is, once the olfactory boundary is passed—smell leads the hard-shelled predator to its next meal. Both critical space and critical situation were terms originally used by Wilhelm Schäfer, Director of the Frankfurt Natural History Museum. Animal societies, he stated in 1956, build up until a critical density is reached, creating a crisis that must be met if the society is to survive.

All animals have a minimum space requirement, without which survival is impossible. This is the critical space of the organism. When the population has built up so far that the critical space is no longer available, a critical situation develops. The simplest way of handling the situation is to remove some individuals. This can be accomplished in a variety of ways, one of which has been developed by *Hyas araneus*. The survival of the species depends on having individuals close enough together to smell each other at breeding time. But the critical space that crabs need is also well defined. When their numbers increase to the point at which critical space is not available, there are always some individuals in the soft-shell stage. Enough of these are eaten to bring the population back to a level at which individuals have enough room.

Several notches above the crab on the evolutionary scale is the stickleback, a small fish that is common in shallow fresh waters in Europe. The stickleback was made famous when the ethologist N. Tinbergen identified the complex sequence the fish has developed to reproduce itself (*see drawing, page 16*). In the spring, each male stickleback carves out a circular territory, defends it against all comers, and builds a nest. His inconspicuous gray coloring then changes, so that his chin and belly are bright red, and his back blue-white; this attracts females and repels males.

When a female, her belly swollen with eggs, comes within range of the stickleback's nest, the male zigzags toward her, alternately displaying his face and his colorful profile. The two-step approach ceremony must be repeated several times before the female will follow the male and enter the nest. Shifting from the visual mode of communication to the more basic one of touch, the male rhythmically prods with his nose at the base of the female's spine until she lays her eggs. The male then enters the nest, fertilizes the eggs, and drives the female away. He repeats this sequence until four or five females have deposited eggs.



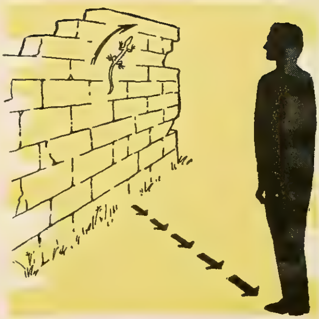
**SOCIAL animals like the hippopotamus require contact with group to survive.**

At this point, the male becomes his former, inconspicuous gray. His role now is to defend the nest and keep the eggs supplied with oxygen by fanning water through the nest with his pectoral fins. When the eggs hatch, the male protects the young fish until they are big enough to fend for themselves. He will even catch those that wander too far (exceed the social distance), and carry them back in his mouth.

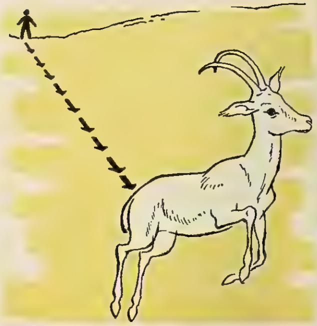
This behavior sequence is so predictable that Dr. Tinbergen was able to conduct a series of experiments that provide valuable insights into the message systems, or signals, that release responses to the different drives. The male's zigzag approach to the female, he postulates, is a response to an urge to attack, which must run its course before the sexual urge takes over. The swollen shape of the egg-heavy female releases the courting response in the male. The female will not lay eggs until she has been prodded by the male, and after she has laid them, his red coloration no longer attracts her. Thus, vision and touch trigger the elements of the sequence.

The predictable nature of the sequence enabled Dr. Tinbergen to observe, in experimental situations, that the presence of too many males with their red coloration disrupts courting. Some steps in the sequence are omitted, so that eggs are neither laid nor fertilized. Under very crowded conditions, males will battle each other until some are killed.

The crab and the stickleback provide useful information about the relation of space to reproduction and population control. The crab's sense of smell is the key to the distance required by an individual and helps determine the maximum number of crabs that can inhabit a given area of the sea. In the stickleback, sight and touch set off an ordered sequence that must run its course if the fish is to reproduce. Crowding disrupts this sequence, and thus interferes with reproduction. In both animals, acuity of the receptors—smell, sight, touch, or a combination of the three—determines the distance at which individuals can live and perform the reproduction cycle. If these receptors are disturbed, the animals lose out to one of their own kind, rather than to starvation, disease, or predation.



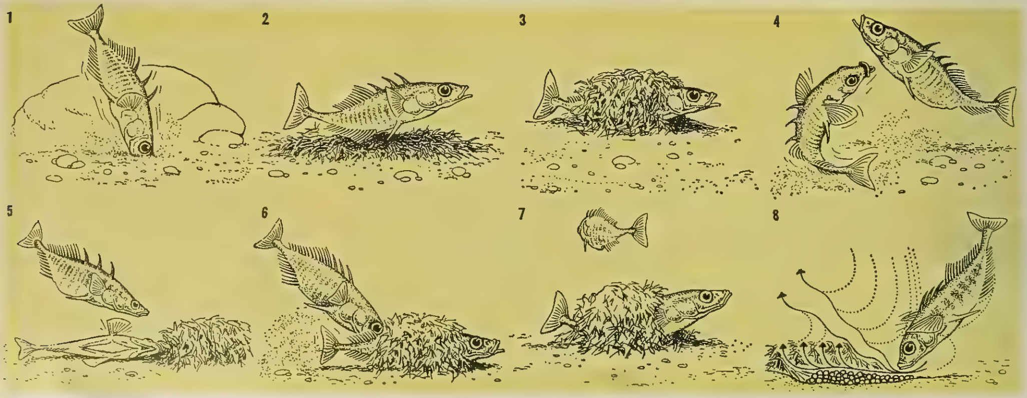
**Critical flight reaction of the wall lizard occurs at approximately six feet.**



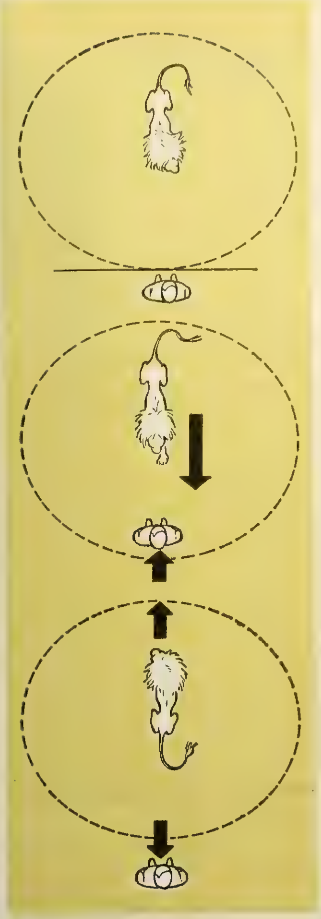
**Antelope will flee when an intruder comes to a point about 500 yards away.**

This seems to call for reconsideration of the Malthusian doctrine that ties population to the food supply. For centuries, Scandinavians have watched periodic migrations of lemmings. Similar behavior has been observed in other rodents and in rabbits at a time of large-scale population build-ups. This behavior has led to some remarkable theories, but it was not until about the time of World War II that some scientists began to suspect that there was more to population control than predators and food supply. At the time of large-scale die-offs that regularly follow population build-ups, there appeared to be plenty of food available, and carcasses showed no signs of starvation.

In 1950, Dr. John Christian, an ethologist with training in medical pathology, advanced the thesis that increase and decrease in mammalian populations are controlled by physiological mechanisms that respond to density, and looked for a chance to study a mammalian population in the actual process of collapsing. About 14 miles west of the town of Cam-

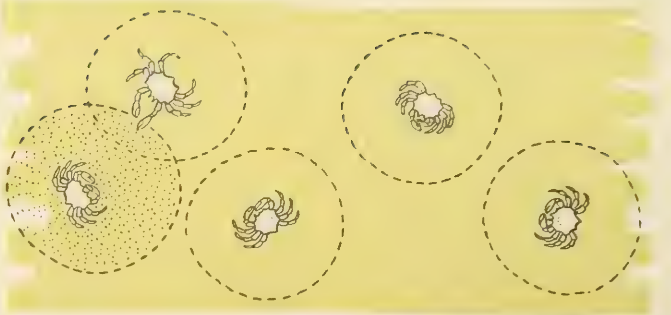


**Male stickleback establishes territory, builds nest, alters color, and lures female to nest in elaborate ceremony. Male nudges female, who lays eggs; he then fertilizes and aerates them, and watches over young until they are on their own.**



**Lion** will pursue a trainer who steps inside critical zone, but it will stop or retreat when the trainer withdraws.

bridge, Maryland, and less than a mile out in Chesapeake Bay, lies James Island, approximately 280 acres of uninhabited land. In 1916, four or five Sika deer (*Cervus nippon*) were released on the island. The herd built up steadily until it numbered between 280 and 300, a density of about one deer per acre. At this point, reached in 1955, Christian began his research by shooting five deer for detailed histological studies of the adrenal glands, thymus, spleen, thyroid, gonads, kidneys, liver, heart, lungs, and other tissues. The deer were weighed; the contents of their stomachs were recorded; age, sex, and general condition were noted, as was the presence or absence of fat under the skin, in the abdomen, and between the muscles.



**Crab,** *Hyas araneus,* unprotected all during its soft-shell stage, is attacked by hard-shelled crab. Crabs at right are beyond the olfactory attraction zone.

Once these records were made, the observers spent a few nights on the island. Later they rowed out daily in a small boat. In 1956 and 1957 no change occurred. But in the first three months of 1958, over half of the deer died, and the following year another drop took place. The population eventually stabilized at about 80 in 1959. What was responsible for the sudden death of 190 deer in a two-year period? The food supply was adequate. All of the deer carcasses collected were in excellent condition, with shining coats and well-developed muscles with good fat deposits. In fact, carcasses examined between 1959 and 1960 resembled those taken in 1956 and 1957 in every outward respect but one. Those taken after the population collapse and eventual stabilization were markedly larger in body size than those taken just before and during the die-off. The 1960 bucks were, on an average, 34 per cent heavier than the 1958 bucks. Does taken in 1960 were 28 per cent heavier than the 1955-57 does. The weight of the adrenal glands of the Sika deer remained constant from 1955 to 1958, during the period of maximum density and die-off. The weight decreased 46 per cent between 1958 and 1960. In immature deer, which formed many of the casualties, adrenal weight dropped 81 per cent after the die-off.

In interpreting Christian's data, it is important to clarify the significance of the adrenal glands, which play an important part in the regulation of growth, reproduction, and the level of the body's defenses. The weight and size of these important glands are not fixed, but respond to stress. When animals are too frequently stressed, the adrenals become overactive and enlarged in order to meet the emergency.

An added factor that undoubtedly contributed to stress was the freezing weather in February of 1958, which prevented the deer from swimming to the mainland at night, as was their custom—a journey that afforded at least temporary respite from crowding. The major die-off followed this freeze. Lack of relief from confinement, combined with cold, which also causes stress, may have been the last straw.

Less dramatic, perhaps, were the late Paul Errington's investigations of predation. In a study of muskrats, he found that more died of disease, apparently as a consequence of lowered resistance due to stress from overcrowding, than were captured by the voracious mink. Muskrats dead of disease were found in one lodge twice in one year. Errington stated that muskrats share with men the propensity of growing savage under stress from crowding. He also shows that crowding past a certain limit results in lowered birth rates for muskrats.

By now, many ethologists have come to the conclusion that the relationship of the predator to his prey is one of subtle symbiosis, in which the predator does not control population but is rather a constant environmental pressure that acts to improve the species. Interestingly enough, little attention is paid to these studies. A recent example is the case of Farley Mowat, who was sent to the Arctic to establish the number of caribou killed by wolves, so that the wolves could be killed off in clear conscience. He found: (*a*) that the wolves killed only a small number of caribou; (*b*) that they were important to the caribou in keeping the herds healthy and strong (a fact the Eskimo knew all along); and (*c*) that hunters and trappers killing caribou to feed their dogs accounted for the decrease in the herds.

It is now recognized that body chemistry working through internal and external secretions helps to control population and to integrate behavior of groups. Just as endocrine secretions tailor body performance to need, secretions from the external glands of one animal can work directly on the body chemistry of another. Parkes and Bruce have demonstrated that the smell of a male mouse can suppress pregnancy in a female mouse.

Another syndrome revolves around bodily responses to stress. Hans Selye, an Austrian working in Ottawa, whose name has been associated since 1936 with studies of stress, demonstrated that animals can die from shock if they are repeatedly stressed. Any increased demand on the organism must be met by the addition of energy. In mammals this source of energy is blood sugar. If repeated demands exhaust the supply of sugar available, the animal goes into shock.

Edward S. Deevey, the Yale biologist, recently explained the biochemistry of stress and shock in a metaphor so effective it should be quoted in part.

"It is possible to speak of vital needs as payable in sugar, for which the liver acts as a bank. Routine withdrawals are smoothly handled by hormones from the pancreas and from the adrenal medulla, which act as paying tellers; but the top-level decisions (such as whether to grow or to reproduce) are reserved for the bank's officers, the adrenal cortex and pituitary glands. Stress, in Selye's view, amounts to an administrative flap among the hormones, and shock results when the management overdraws the bank."

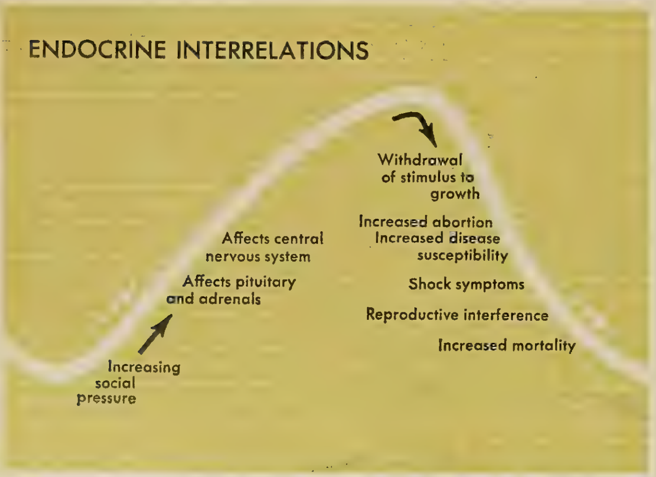
The reader will remember that the Sika deer showed greatly enlarged adrenal glands just before and during the die-off. This increase in size was presumably associated with increased demands for ACTH (a hormone that reinforces the adrenal cortex), which were due to increased stress from crowding. Following this lead, Christian in the late 1950's made a study of seasonal changes in the adrenal glands of woodchucks. Among the 872 animals collected and autopsied over a four-year period, the mean weight of the adrenals increased as much as 60 per cent from March to the end of June, a period when the woodchucks were active for longer portions of the day, more of them were concentrated in a given area at the same time, and aggressiveness was high during the breeding season. The weight declined in July, when the greatest number of animals were active but aggressiveness was low. The weight rose sharply in August, when there was extensive movement among young woodchucks and possibly many conflicts.

It is now widely held that the processes of selection that control evolution favor the dominant individuals in any given group. Not only are they under less stress but they also seem to be able to stand more stress. Christian, in a study of the pathology of overpopulation, showed that the adrenals work harder and become more enlarged in subordinate than in dominant animals. Also, his own studies showed a relationship between aggressiveness and distance between animals. When aggressiveness increases, the animals need more space. If none is available, as when populations are approaching a maximum, a chain reaction is started. A blowup of aggressiveness and sexual activity, and accompanying stresses, overload the adrenals. The result is a population collapse due to lowering of the fertility rate, increased susceptibility to disease, and mass mortality from shock. In the course of this process, the dominant animals are favored and usually survive.

The provision of individual territories for families and the screening of animals from each other at critical times during the mating season can counteract the ill effects of crowding down to and including animals low on the evolutionary scale. The more our knowledge of animal behavior increases, the more evident it becomes that man cannot escape the fact that he is an animal. This fact is nowhere more evident than in man's use of space. Talented animal that he is, man has shrunk the globe, thus reducing the space available for interaction.

If we tend to deplore the results of crowding, we should not forget that the stress it produces has had positive values. Such stress has been an efficient device in the service of evolution because it employs the forces of intraspecies competition rather than the interspecies competition that is more familiar to most of us as nature "red in tooth and claw."

Present assumptions about the evolution of man illustrate the effects of both pressures. Originally ground-living animals, man's precursors were forced by interspecies competition and changes in the environment to desert the ground and take to the trees. Arboreal life calls for keen vision and decreases dependence on smell, which is crucial for most terrestrial organisms as an important medium of communication. This lack of development in man's sense of smell may have endowed him with greater capacity to withstand crowding. If humans had noses like some other


ENDOCRINE INTERRELATIONS
Withdrawal of stimulus to growth
Affects central nervous system
Affects pituitary and adrenals
Increasing social pressure
Increased abortion
Increased disease susceptibility
Shock symptoms
Reproductive interference
Increased mortality

**Endocrine** interrelations chart was a result of studies of the Sika deer herd.

mammals, they would be forever tied to the full array of emotional shifts occurring in persons around them. We could smell other people's anger. The identity of anyone visiting a home and the emotional connotations of everything that took place would be easily distinguished. The psychotic would begin to drive all of us mad, and the anxious would make us even more anxious. To say the least, life would be much more involved and intense. Also, it would be less under conscious control, because the olfactory centers of the brain are older and more primitive than the visual centers.

The shift from reliance on the nose to reliance on the eye as a result of environmental pressures has completely redefined the human situation. Planning has been made possible, for example, because the eye takes in a larger sweep; it codes vastly more complex data and thus encourages thinking in the abstract. Smell, on the other hand, while deeply emotional and sensually satisfying, pushes in just the opposite direction.

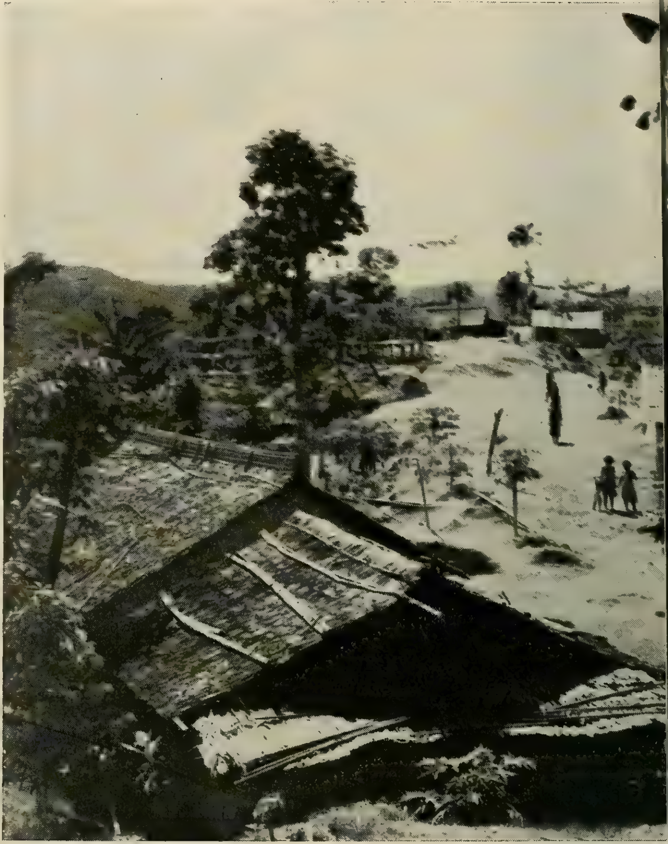
Man's evolution has been marked by the development of "distance receptors"—sight and hearing. Thus, he has been able to develop arts that employ these two senses to the virtual exclusion of all the others. Poetry, painting, music, sculpture, architecture, and the dance depend primarily on eyes and ears. So, of course, do the communications systems of man.

Thus, man's arboreal past, his self-domestication that led to an elimination of the flight reaction, and the development of sensory and thermal screens have radically altered his responses to crowding, making it possible to pack more people into a given space than if these changes had not occurred. However, man's biochemical responses to stress are still well within the pattern established for other mammals and, while he is an extraordinarily tough animal, his ability to withstand stress is not unlimited. There has been growing concern among a few scientists, at least, that man may be approaching (if he has not already done so) the limits of his tolerance for crowding, particularly in the more depressed urban areas. There can be no doubt, however, that he is much involved in the space experience.

**MAN'S defense against overcrowding is to develop thermal and sensory screens.**

## POLITICAL FINANCE IN MELANESIA

# Big Men and Disks of Shell



Melanesia, an ethnic region composed of islands in the Pacific Ocean northeast of Australia, was once thought to be an area of remarkable cultural uniformity, but now it is becoming known as an area of remarkable diversity. For instance, we can no longer refer to Melanesia as "the matrilineal sea." Instead we find there social forms that are frequently variations on such a well-known organizational theme as matrilineality, but which also include patrilineality and even cognatic or "bilateral" descent. Some of these forms are unique to Melanesia and provide interesting grist for the mills of anthropological theory. However, despite the variation in kinship structure, there remains a common organizational theme, the competition among "big men"—those who acquire prestige and power through the manipulation of the allegiances of other men. And it is this kind of activity that passes for politics in these societies.

Important in this political process is the control of basic resources, such as land, pigs, and other "valuables." The latter are often items processed from shell of various kinds, including those made from gold lip, cowrie, and bailer shell that are found throughout large areas of New Guinea. These shell valuables, like our dollars, have no intrinsic productive value but are of considerable symbolic significance. They are valuable, not in themselves, but for what men do with them, and their significance lies in the activities through which they are acquired and subsequently redistributed. Dr. Bronislaw Malinowski, the noted ethnographer, tells us in *Argonauts of the Western Pacific* how the Trobriand Islanders give each *kula*—a necklace or armband of shell—a personal name and how men fondle them and treat them as pets. However, a recent reanalysis of the "*kula* ring"—a pattern of interisland trade in which *kula* valuables flow in one direction and goods of practical value in the other—has suggested that it is the political significance of these valuables that partly accounts for their importance. Perhaps more than Malinowski realized, the "big man" system of politics operates in the Trobriands, too, and *kula* exchange in its various forms is, or was at one time, an integral part of acquiring political eminence.

Although they vary widely in form and significance, shell valuables are common throughout Melanesia. The shells are processed, converted into valuables, and sometimes traded over long distances, as from the coastal areas to the remote highlands of New Guinea. In such instances, their value increases proportionately with the distance from their source of manufacture. Sometimes they function very much like money, that is, as a more or less universal standard of commercial exchange, but they are also frequently used in social contexts in which we would find monetary exchanges inappropriate. Bride price transactions are a notable case in point. There are few markets in Melanesia, and daily provisions are seldom bought and sold; thus, while shell valuables are, in a sense, monies, they are best thought of as limited-purpose monies.

The most-cherished and, until the twentieth century, the most politically significant valuable on the island of by **HAROLD W. SCHEFFLER**

INLAND village of Baukolo, now poor, once had an illustrious line of leaders.

CHOISEUL man's nine shell arm rings, or *ziku*, mark his "big man" position.

Choiseul, in the British Solomon Islands Protectorate, is called *kesa*. (Choiseul is known as Lauru by its inhabitants.) *Kesa* consists of sets of shell cylinders, probably giant clam, *Tridacna*, and each set usually consists of nine small tubes that are bound together in a single leaf package (*see photographs on following page*).

To the best of my knowledge *kesa* is yet to be described to the Western world, and other than the pieces I possess, I do not believe that there are any complete sets extant outside of Choiseul. Most other items of ethnographic interest on Choiseul have long since been carted off by passing curiosity seekers. Today *kesa* has lost most of its social utility because of the changes consequent to pacification and missionization since 1900. Yet, it still remains valuable in and of itself, and the few big men who own it will not part with it for any amount of money that may be offered.

When one asks a Choiseulese what *kesa* is made of, he is not able to say, for as far as he knows, humans had no part in its making. According to ancient tradition it was made and given to man by *bangara Laena*, a water god. Long ago, so goes the story, *Laena* thought to himself, "I am the god of Lauru, and I must make something important for Lauru, something that can be the 'mark' of the big men there." He thought of *kesa*, but the first two attempts at manufacture proved abortive. There were too many or too few pieces to each set, and he was not satisfied with his handiwork. He tried a third time and then produced *kesa* with nine pieces to a set, and this pleased him. He sent word to the men of Choiseul to erect a large house at a place called Nuatambu, on the north coast. Each of the six dialect areas was told to prepare a pig for presentation to *Laena* and then to come to Nuatambu to receive *kesa* and instruction in its use. (It was to become the custom that baked pig should always accompany the exchange of *kesa* in any transactions.)

When *Laena* brought the *kesa* ashore—he is said to have manufactured it in the ocean's depths—he placed the larger varieties in the rear of the house and the smaller and less valuable varieties in the front near the entrance. When he finished, the house was full. Then the people arrived in their canoes from all over Choiseul, and *Laena* said to them, "There is the *kesa*, help yourselves!" They presented their pigs to him and began to gather it up. The people from the Varisi, Taula, Bambatana, and Ririo areas, to the north and west, were quick. They entered the house first and gathered up the small *kesa* that completely blocked the front entrance. The Sengga and Kumboro people, from the southeast areas, were slow and had to go through the rear entrance. Thus they were able to collect the large *kesa.*

As the people helped themselves, they fought over possession of it. Each big man said to the other, "I will take plenty for myself alone," and as they snatched it from one another, much of it fell to the ground and was smashed. Now when one goes to Nuatambu, one can see hundreds of broken sherds of *kesa* strewn about on the beach.

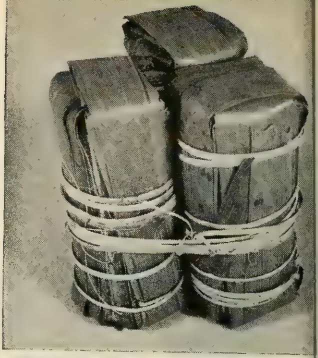
*Laena* promised to come again and bring more *kesa.* He told the people to go home and await his message. But it was not long after that he became involved in a contest of strength with another god, *Nggola*, a snake, and lost his life by being baked in an earth oven. That is why, the story goes, that there is so little *kesa* today. Had it been brought ashore more than once there would have been plenty for everyone, but as it was, only the important men could have it, and so a man could acquire it only by diligent competition with other men.

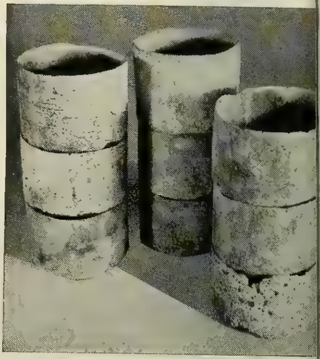
A visitor to Choiseul will note that *kesa* looks suspiciously like fossilized shell, but he will have difficulty figuring out how it might have been made. There are other forms of shell valuables relatively common throughout the Solomons, such as large polished rings of clamshell. Some have reddish streaks running through one edge, giving them a higher value. These, called *ziku kesa* by the Choiseulese, are commonly known to have been made even in recent years by a process of pecking and rubbing the shells on sandstone or pumice and finally by drilling with fine sand and bamboo. It may be that *kesa* was made in a similar way, but one can only guess. Informants assured me that it is true, as the story reports, that many fragments of *kesa* are to be found at Nuatambu, but I did not see the place and even if I had, I might not have known whether it was the manufacturing site or simply a place where much *kesa* was broken.

I saw only a few sets of *kesa.* Today, most men will disclaim possession of any lest someone try to borrow it, but at the same time they are so ambiguous in their replies to queries that one is not sure. On more intimate acquaintance they may offer to take one to see where it is hidden—to prove that they are truly big men. I saw more come to light in the occasional bride price transactions, but *kesa* "doing work" (used as money) is a rare sight today.

*Kesa* is all the same in form—nine thin-walled cylinders per set—but is widely variable in size, in quality and, therefore, in value. There appears to be no definite standard of value against which it has ever been compared. For instance, one of the few things it can purchase is pig, but the transaction depends upon the quality of the shell valuables, the quality and size of the pig, and even the quality of the interpersonal relations of the people involved. Recently, the Choiseul Council decided that the smallest *kesa,* which was once commonly used in transactions, is worth three pounds in Australian currency (about $6.75). Others are said to be worth up to ninety or more dollars, but this is an arbitrary evaluation. In the past, if one did not have *kesa,* one could substitute ten *ziku*—arm rings also made of clamshell. However, then as now, no one would trade ten *ziku,* or three Australian pounds, for one *kesa.* Thus these equivalences are purely utilitarian—for substitution in transactions in which *kesa* is preferred.

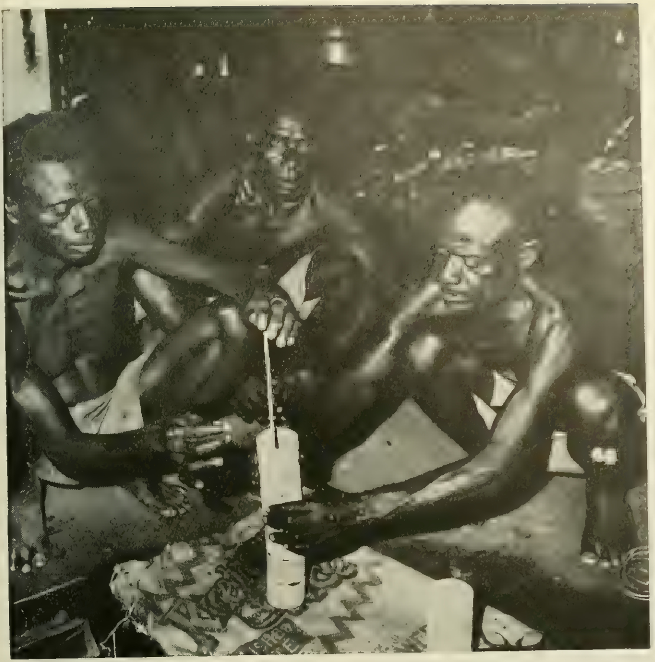
The smaller variety of *kesa* is often termed *kesa zazu, kesa* that "works," or *kesa soka, kesa* for "exchanges."





**Nine** shell disks, *above,* wrapped in sago palm leaves, *top,* make a *kesa.*

**Islander** shows his *kesa,* in bundles at left, and his *ziku kesa,* in pot, to prove his claim to status. He had buried the valuables for safekeeping.



**Procedure** in *kesa* transactions is to stack the cylinders and measure their height with the midrib of a sago palm leaf, which also serves as a support.

The larger variety is simply "large *kesa*," which, in the past, was seldom used in transactions but was kept as security against attack or vengeance.

Working *kesa* comes in five sizes, each of which is valued at three times its "size" in Australian pounds. Thus *kesa potaka kavasi* ("worth four") is the equivalent of twelve Australian pounds (about $27.00). A set of *kesa potaka kameka* ("worth one") was presented to me when I left Choiseul in 1960 after a fifteen-month visit. In this set, each of the nine rings is approximately two and three-quarter inches wide and one and three-quarter to two inches long. They are approximately one-eighth inch thick at the center of the cylinder and taper to paper thinness at the edges. Each cylinder is known as one *mata*, or eye, and three *mata* make one *salaka*, a term for which there is no English equivalent. Each *salaka* is then bound together in a sago palm leaf, and the three *salaka* are tied together to make up a single triangular package known as one *kesa*. "One *kesa*" is thus a conveniently ambiguous term, for it may refer to a set "worth one" or to a single set of any size. (*Mata* and *salaka* are never used singly in transactions.)

The small *kesa* I have is about seventeen or eighteen inches tall when all nine *mata* are stacked edge on edge. The Choiseulese "stand up the *kesa*" in this way during transactions in which it must be examined meticulously for size and quality. The length of the set is then measured against a rod made from the midrib of a sago palm leaf that is placed inside the stack and that also prevents it from toppling over (*photograph above*). Arranging the *kesa* to stand up on its own is no mean feat, and it may require several hours of patient manipulation of the uneven, jagged cylinder edges. Only old men are thought to have the necessary skills.

When the *kesa* is finally stacked, usually before an audience that offers advice about the process, the palm leaf rod is broken off even with the height of the *kesa* and then measured against the human arm. The smallest working *kesa* should reach approximately from the finger tips of an outstretched hand to about three inches below the inner crook of the elbow. The fifth and largest of this type should reach to the center of the biceps. It is obvious that these measurements vary from person to person, and the variation leaves room for debate as to the relative worth of particular sets. (Some men used to mark the lengths of the various *kesa* they had owned or were owed on the handles of their war clubs.) A set's value is also dependent in a vague and not readily calculable manner upon its condition as well as its size—again leaving room for debate about the equivalence of transactions.

Large *kesa* also comes in a variety of sizes, and some unusual and highly valued sets contain eight or ten rather than the usual nine cylinders. I recorded the names of some nine varieties whose values are said to range from sixteen pounds Australian to extremely valuable, and I once saw one reputed to be worth ten times the standard one *kesa*, or thirty pounds (about $68.00). When it was standing up, it was about the length of one's arm from shoulder to finger tips. The largest *kesa* seen by anyone I spoke with was said to be six feet long, with individual cylinders that measured from the tip of the thumb to the tip of the small finger over an outstretched hand (some eight to nine inches).

In addition to working *kesa* and large *kesa*, there are some sets that are exceptionally small. There is, for instance, *napukana*, somewhat smaller than the standard one *kesa*, which was used in the past only in peacemaking transactions and was said to bring a war to an unequivocal end. To accomplish peace the disputing parties would agree to exchange *kesa*, one side always using *napukana*.

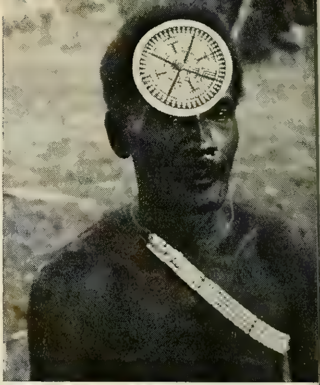
Valuable as it was in Choiseul tradition, in terms of political as well as economic prestige, *kesa* was the object of much jealousy, envy, connivance, and thievery. Disputes over ownership, debts, or whatever, were among the principal sources of Choiseulese conflict until about 1920, and it was very important to keep the amount and hiding place of one's valuables as secret as possible. This secrecy helped prevent continual demands for loans from one's less fortunate relatives, and also made for a margin of uncertainty as to one's political potential. Successful men were those who were clever at getting and circulating *kesa,* but they also had to be able to convey the impression of wealth when they were temporarily indisposed.

As noted earlier, *kesa* may be called money only in a restricted sense because it is not and never was a universal medium of exchange. Indeed, such universal mediums are fairly rare in the primitive world. More often, valuables are of limited utility, and the range of situations in which they are useful is narrow. On Choiseul, *kesa* was traditionally too valuable to use in the myriad of minor transactions between kinsmen, who would give and receive assistance in any event. Reciprocation, not payment, was expected. Its most important uses were in bride price payments and in the formation of alliances between individuals or groups for purposes of vengeance. Although it was sometimes used to pay for a canoe or to purchase a pig for a feast, there was usually no such obvious material gain in the transaction. *Kesa* was also exchanged with other men through a process of competitive feast-giving and in a manner reminiscent, although not strictly comparable, with the well-known potlatches of the Indians of the American northwest coast.

These competitive feasts were called *kelo,* and although they are no longer given, they were once the outstanding public events of Choiseulese life. A big man might arrange several during the course of his career, and the most powerful men gave perhaps as many as ten or more. The feasts required the joint efforts of a large number of people—usually members of the big man's kin group and his followers. Assistance came, too, from outsiders who hoped to benefit from the occasions. The benefits received might be in kind, perhaps at a later date when the former helper turned principal party in another transaction. But a big man's followers usually rendered assistance for less tangible but equally important returns in the form of protection and security. This was a society without "law" in our more formal sense of the term, and in order to comprehend the sense of social life on Choiseul (and in Melanesia in general) we must note that a man could attain and maintain his political and economic interests only through other men and only by force or agreement. The obligations one managed to impose on others were an important form of capital. To protect life and property one either had to become a big man, or else secure the protection of one by helping him realize his ambitions.

Renown would accrue to a man who organized and executed gift exchanges, but these were not undertaken solely for profit in *kesa.* It was desirable to come out ahead, but in some forms of exchange it was the giving and the doing that counted most. Indeed, these transactions called *kelo* were important precisely because they "made one's name go out"; they demonstrated one's abilities as a manager of men and goods. Thus men were sometimes tempted to challenge others to a round of exchanges on a conventional but rather meaningless pretext. For instance, if Tanakesa's father died, one of his more remote, but friendly, kinsmen might challenge Tanakesa to a series of exchanges by offering to provision and direct the funeral feast. At a later feast, the kinsman would be presented with *kesa,* and he might follow with still another feast, returning part of the kesa. The amount returned would depend on whether he wished to continue competition and whether he knew Tanakesa would continue too.

These meaningless exchanges, or exchanges "without bottom" as the Choiseulese called them, were common enough before 1920, but the most significant *kesa* transactions grew out of contractual political alliances between big men. Let us suppose that Tanakesa, whose very name would mean "one who seeks after *kesa,*" was a big man. He had to take revenge for any offenses against himself or become known as one who could be offended with impunity. The first thing he had to do was "size up" his opposition. If he felt they were weak in *kesa* or potential allies (remember that much of one's potential might be in the hidden form of debts owed to oneself by others, as well as in immediate possessions), he then sought revenge in one of two ways. He could arrange the assassination of the culprit or one of his kinsmen, or he could organize a raid upon the culprit's village in which many people would be sure to die. Which course he chose depended in large part upon his reserves in *kesa* or upon the outstanding obligations of others to help him. Either way he would probably not have undertaken to carry out the revenge himself, but would have contracted another man or group to do it for him. In this way he could hold a feast and gift exchange to pay the agents the *kesa* that had been promised them. But the transaction did not end there. The agents were also obliged to give a feast at which they could return, again, either more or less *kesa.* (Returning more would have been a way of stating a claim for more *kesa* for the services that had been rendered.)



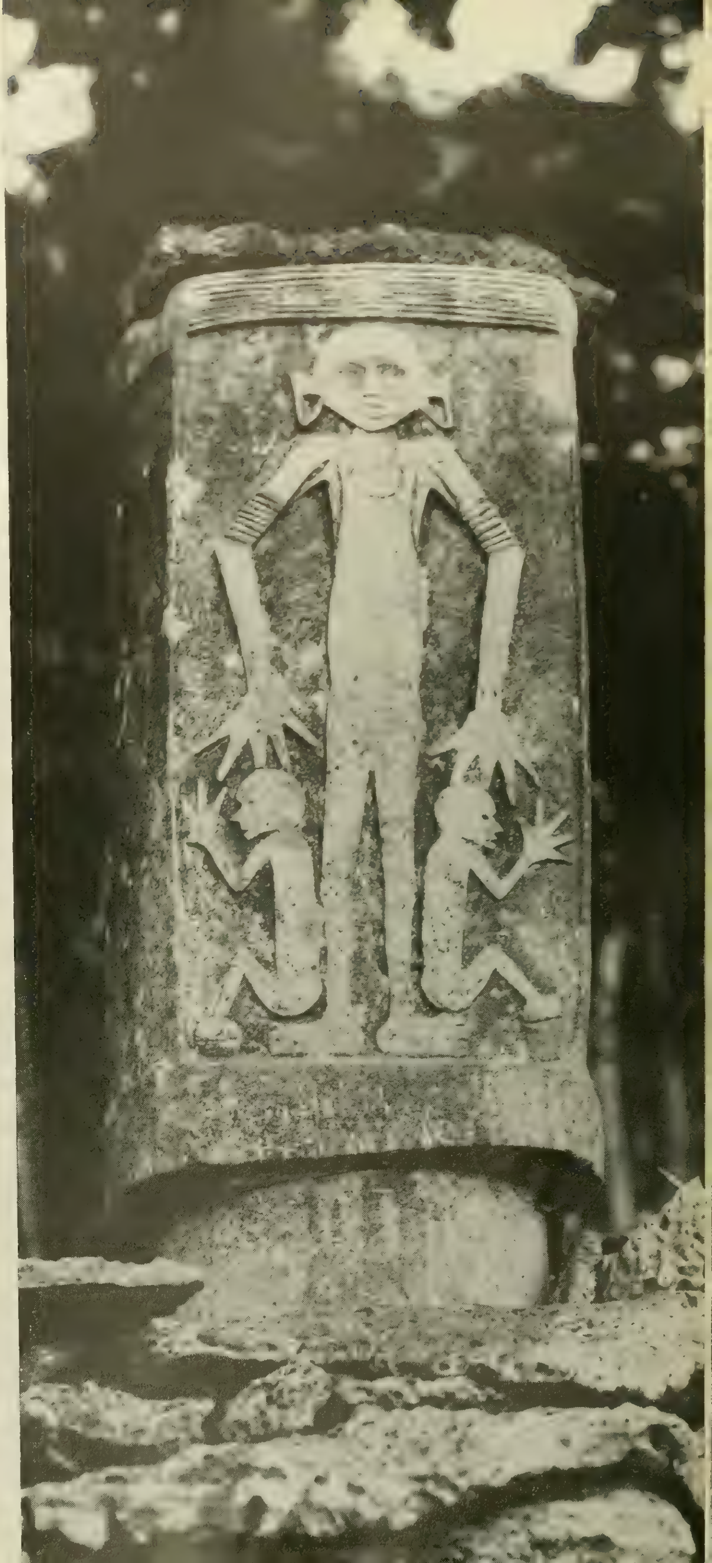
**Leader** wears clam- and turtle-shell ornament and a strap of shell beads.

Seldom did exchanges go much further than two or three rounds, even though, ideally, competitors should have wanted to exchange *kelo* until they were incapacitated through depletion of resources. Although they usually did not act in this way, they sometimes fostered the impression of having done so in order to postpone their own payment of debts or to implement collection from debtors. Such exchanges were not always so simple, and often there was a great deal of wrangling over debts and their payment. Also, kin groups often recruited more and more allies for the big man in a chainlike fashion and so organized large war parties. There then followed a "chain of *kelo,*" which usually meant a long postponement of final settlement of any dispute. What is more, it often led to quarrels among the big man's supporters.

This process of acquiring debts and credits gradually led the big man into a web of obligations that could act to constrain violent outbreaks as well as to provoke them. Groups and their leaders would often refrain from conflict in favor of a period of co-operation, and there could be periods of peace throughout an area. Thus, some aspects of interpersonal and intergroup hostilities helped to constrain conflict as well as to aggravate it.

Still, this way of life was an unstable one in many ways, and it was easily toppled by external as well as internal influences when European contact became intensive in the area toward the end of the nineteenth century. While the Choiseulese found satisfaction in competition and violence, they also found it in peace, and it was only in times of peace that men could meet the obligations incurred during conflict. Established in the 1890's, the British protectorate, with its firearms and superior forces, soon convinced the islanders that Europeans could play the game better than they could. In addition, the Christian missionaries who arrived early in the 1900's provided a rationale for peace in Christian dogma, and they credit much of their success to the islanders' desire for peace. Still another powerful force for change was the Melanesian attraction to European material goods, and it may well be that peace was accepted out of economic necessity. The islanders could get the goods they coveted only by engaging in the copra trade with Europeans, and settled internal conditions were essential to its development. In any event, the acceptance of peaceful conditions proved the undoing of much of the indigenous culture, and the Choiseulese have for some forty or more years been a peaceful oceanic peasantry completely dependent upon the copra trade for their mode of life. (In fact, intergroup violence is not permitted today by the protectorate courts and councils, nor is there any inclination toward it.)

*Kesa,* like the rest of the indigenous culture, has little meaning on Choiseul now, although men are more attached to it than, perhaps, to anything else in their past. Some Choiseulese accept responsibility for the demise of their former way of life, saying, "We killed it ourselves." Clearly the choices were not always theirs to make. Much that happened was quite beyond their ken or control, although without outside "assistance" they could not have done much to ease their internal conflicts.



**Limestone** burial urn holds the ashes of several "big men" of a kin group.

# "Sleeping One" of the Hopis

## One desert oddity is a hibernating bird

By Edwin Way Teale

"Swallows certainly sleep all winter. A number of them conglobulate together, by flying round and round, and then . . . throw themselves under the water, and lie in the bed of a river."

Thus, in the year 1768, Samuel Johnson explained the disappearance of these birds in fall to his biographer, Boswell. He was expressing—with Johnsonian finality—the prevalent belief of his time. In *The Natural History of Selborne,* Johnson's contemporary, Gilbert White, noted that one eminent Swedish naturalist of the period talked "as familiarly of swallows going under water in the beginning of September as he would of his poultry going to roost a little before sunset." With the passage of time, the absurdity of this idea grew obvious. A better understanding of migration explained the mystifying disappearance of birds in fall, and Johnson's "conglobulating" swallows became recognized as a classic misconception. Through the nineteenth century and the first decades of the twentieth, the belief in hibernating birds stood as a symbol of human credulity.

It was against this background that Dr. Edmund C. Jaeger, in the Chuckawalla Mountains of the Colorado Desert, on December 29, 1946, discovered a hibernating bird. On the same December date of a later year, Dr. Jaeger and I returned to the scene of his discovery. With Gregory Hitchcock, an early exploring companion of his, at the wheel of a green jeep, we ran east from Lucerne Valley to Twentynine Palms, turned south through the Joshua Tree National Monument, then swung east again toward Desert Center.

In one of his books, Dr. Jaeger has observed that "the desert landscape is monotonous only to the uninformed." Mile by mile as we advanced, our surroundings became more interesting by virtue of his comments and explanations. They were drawn from a lifetime of desert study. In his mid-seventies, the recognized authority in his field, he retains all the passionate interest in the interrelating life of these dry lands that has guided his activity for more than half a century.

Almost every week end, he heads for the desert. Over a period of more than thirty years, he once calculated, he had spent at least two or three nights of every week in his sleeping bag. Formerly Chairman of the Department of Zoology at Riverside Junior College, he usually takes along on his trips two advanced students. By preference, one is a good cook, the other proficient in the handling and repair of automobiles. Thus he is left free to study.

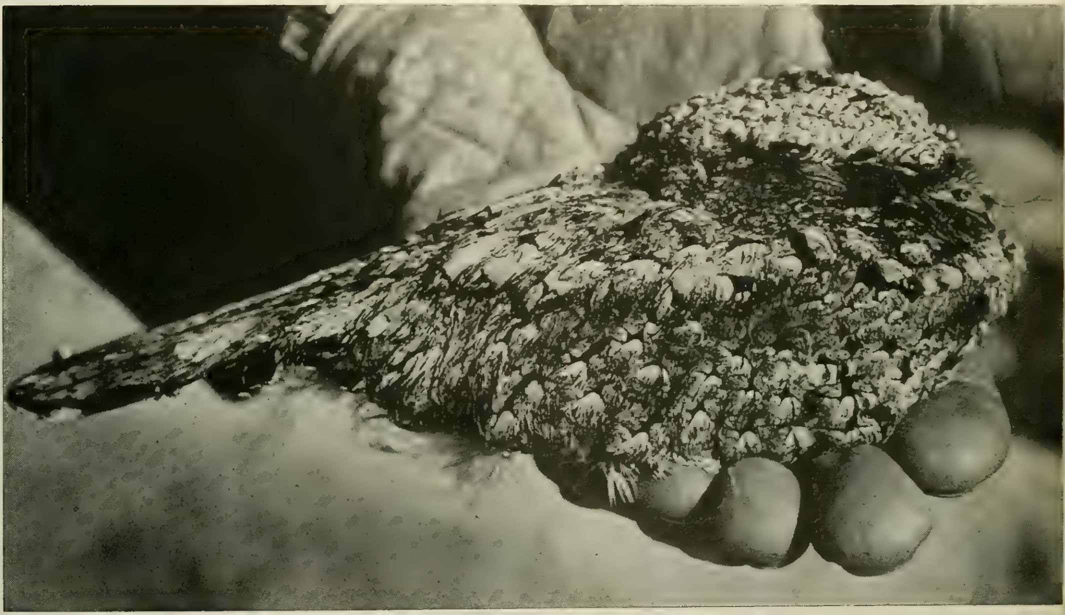
In his absorption with the desert, Dr. Jaeger represents a type of natural history specialist that is coming to have increasing importance in science. Instead of specializing vertically, as in a lifetime spent on a restricted subject like duckweed or moss animals or feather mites, such an authority will specialize horizontally. All life within an environment will be his province. He will devote himself to every aspect of his chosen area—meadow, timberline, swamp, or mesa—as Dr. Jaeger has devoted himself to desert life.

We had been gradually descending as we advanced. East of the Little San Bernardino Mountains, we left the Mojave behind. We were in the lower Colorado Desert when we swung off the highway onto wheel tracks that led us across a dry, flat land, broken here and there by immense mounds or hills of jumbled reddish rock. In the sunset, they stretched long shadows toward the higher masses of the barren Chuckawallas. When we made camp in the protection of one of the piles of weathered rock, dusk had almost fallen.

The desert, it has been said, is all geology by day and all astronomy by night. And I was seeing its sky in winter, in the season of stars. To most people, the winter constellations are the most familiar. We see them then in clearer air, in a time of earlier darkness, when foliage is off the trees. Here the Great Dipper was below the horizon, and Orion shone higher in the sky than at home. Lying there, I stared at the Pleiades above me and at the blue star, Sirius, in Canis Major, the brightest in the night sky. Several times meteors drew swift lines of flame among the stars.

After three o'clock that morning, my mind was occupied largely with the mystery of the birth and death of the desert wind. During the early part of the night, the air was calm. Then, virtually without warning, gales of erratic wind began to blow. They came in a long sequence, reaching a peak, dying away entirely, then rushing upon us once more. What brought them into being, what caused them to stop, I could not fathom. Although I have questioned many people since,

**Dr. Jaeger** and author examine holes where bird was discovered. Eroded rock formation, *left*, is in the desert near Chuckawalla Mountains. Hibernating Poor-will, shown in Dr. Jaeger's hand, remained in torpid state despite tests.



the mechanics of that strange night wind remain a riddle. The broken surface of the desert floor, the proximity of the rock of the mountains, the innumerable canyons nearby—all these probably play a part.

On and above the surface of dry land, the rapid fluctuations of temperature produce violently shifting air currents. Wind is so much a part of desert life that a number of creatures have developed special adaptations in consequence. On the Mojave Desert, Dr. Jaeger has noted a small blue butterfly, *Philotes speciosa*, alighting on a windy day and hooking the three legs on one side to a pebble, letting the gusts blow it over parallel with the ground. In this position it offers the least resistance to the wind.

The pressure exerted by moving air mounts rapidly as the velocity of the wind increases. At fifteen miles an hour, it is slightly more than one and a tenth pounds to the square foot. It has been calculated that a fifty-mile-an-hour wind—a not unusual gust in that desert—pushes against a cliff half a mile long and a hundred feet high with a pressure of 33,000,000 pounds. I was a noticeably smaller object. But in the heavier onslaughts I seemed on the verge of rolling away, like a tumbleweed, in my sleeping bag.

Toward the end of each lull, I could hear the new wind coming like an onrushing train. I would snuggle farther into my sleeping bag, pull in my neck like a turtle, and let the gale pound me as it rushed by. I timed the lulls between the gusts as the stars paled and a faint pink flush spread up from the east. That day—like the night that had preceded it—was no ordinary one. There were few signs of the season around us. Throughout much of the year, the desert has a bare and wintery look. Even the living plants appear parched and yellow. We bent to examine the curiously swollen stem of a desert trumpet, *Eriogonum inflatum.* The plant, which rain would turn green again, was dry and parchment-like. One of the small hunting wasps employs the inflated stems of this wild buckwheat as storage chambers for the paralyzed insects on which its larvae feed. It bores a hole near the top of a stem, fills the lower part of the cavity with tiny pebbles, then deposits its prey and its eggs. Over them it places more pebbles and sand. Under such conditions the young wasp hatches, grows, transforms into an adult, and makes its way to freedom.

Also dead-appearing in their dry surroundings were many of the slender wands of spiny ocotillo, which rose in clusters from the desert floor. All through the year, in a series of short growing seasons following rains, these rodlike, unbranched stems put forth small leaves. Each time, as drought conditions return, the leaves change from green to red and fall away. Once we came upon a clump in which each wand was still clothed from top to bottom with red-tinged foliage.

In pioneer times, ranchers sometimes improvised stockproof fences around corrals by cutting off the thorny stems of ocotillo and planting them in the ground, where they took root. Under favorable conditions, one of these wands may rise to a height of twelve or even fifteen feet. Its bark is rich in resin-like wax. One of its common names, candlewood, is derived from the steady, deep-yellow flame with which it burns. It is in the spring, when all the wands are tipped with scarlet flowers, that the ocotillo most deserves the *splendens* of its scientific name, *Fouquieria splendens.*

Another curious wand, gray-green, smooth, waxy, and limber, rose at times higher than my head from among rock jumbles of the mountainside. When prospectors roamed the western deserts with burros, these stems, strong and pliable, were used as whips. I noticed that where the skin of one wand was broken near the tip, thick, milky sap was oozing out. The gray-green wands formed the complete plant of the desert milkweed, *Asclepias albicans.* As I was looking at this naked plant, and accepting the fact that it *was* a milkweed, my mind returned—as it did more than once during these desert days—to the White Queen, who remarked to Alice behind the looking glass: "Why, sometimes, I've believed as many as six impossible things before breakfast."

**"Sitting woman" rock is near entrance to small canyon where bird was found.**

Past a dozen clusters of these slender wands, we worked our way upward among tumbled boulders that choked the mouth of a small ravine. At the top we came out on a floor of pale-gray sand between walls of granite. At the opposite end of the canyon, the entrance was even more dramatic. On one side of this mountain portal, a pinnacle—a spire of reddish rock—towered in the air. On the other, a titanic mass of similar stone had weathered into the form of a sitting woman. Only a hundred yards or so in length, only a few yards wide at the bottom, this small canyon seemed specially marked by nature as though in anticipation of some event in which the ravine would play a part.

That event had already occurred in 1946. The ravine was the site of Dr. Jaeger's historic discovery. By the merest chance, on that December afternoon, as he and two of his students passed through the canyon, they had caught sight of a western relative of the whippoorwill, a Nuttall's Poor-will, lost in its winter sleep.

I had imagined the bird was found in some deep fissure, well hidden from sight. But when Dr. Jaeger pointed out the spot, I was amazed to see it was only a small, concave depression in the granite wall, hardly larger than my cupped hand. It was roughly five inches high, four and a half inches wide, and four inches deep. Into this rounded depression, with its head up and its tail down, the bird had pressed itself. Its mottled gray and black plumage almost perfectly matched the coloring of the rough granite.

A thing may be found many times and still be lost. It must be recognized as well as seen. The chance discovery of the Poor-will was important. But a comprehension of the significance of what was found was more important. Prospectors, Indians, children, hunters, all may have come upon sleeping Poor-wills in the desert. The winter dormancy of the bird apparently was known to the Hopi Indians. Their name for the Poor-will is "The Sleeping One." But Dr. Jaeger was not only the first scientist to see the bird in hibernation but the first to comprehend the importance of what he found. He also followed up his discovery with careful, detailed studies. He photographed, measured, weighed, and banded the bird. He returned to the canyon for additional observations many times during four winters.

On this first encounter, he touched the Poor-will, stroked its feathers, even picked it up without disturbing its torpor. As he was returning it to its niche, it slowly opened one eye and sleepily closed it again. That, Dr. Jaeger told me, was the only sign he had that it was a living bird. During four hibernating seasons, extending from 1946 to 1950, the canyon was the scene of additional scientific study. The numbered aluminum band revealed that the same individual was returning year after year to sleep the winter away in the same niche in the same small ravine.

The normal temperature of a Nuttall's Poor-will is about 106° F. When fortnightly temperature readings were taken over a period of six weeks in 1947, they showed the body heat of the hibernating bird had sunk to a low of 64.4°. Its breathing was so shallow and infrequent that no movement of the chest walls could be noted, and when a cold metal mirror was held close to its nostrils, no moisture collected on it. Even when using a stethoscope, Dr. Jaeger was unable to detect the slightest sound of a heartbeat. So low had the flame of life sunk that bodily functions had all but ceased.

In the sand below the niche in which the Poor-will had lived for successive winters, I noticed the tracks of coyotes. Apparently, the narrow canyon formed a regular path followed by these predators. When I measured the distance, I found the niche was hardly more than two feet above the sand. Yet, so effective was the bird's camouflage that it had been passed and repassed while virtually on an eye level with the hunting coyotes. In its torpid state, with its organs barely functioning, it apparently gave off virtually no odor.

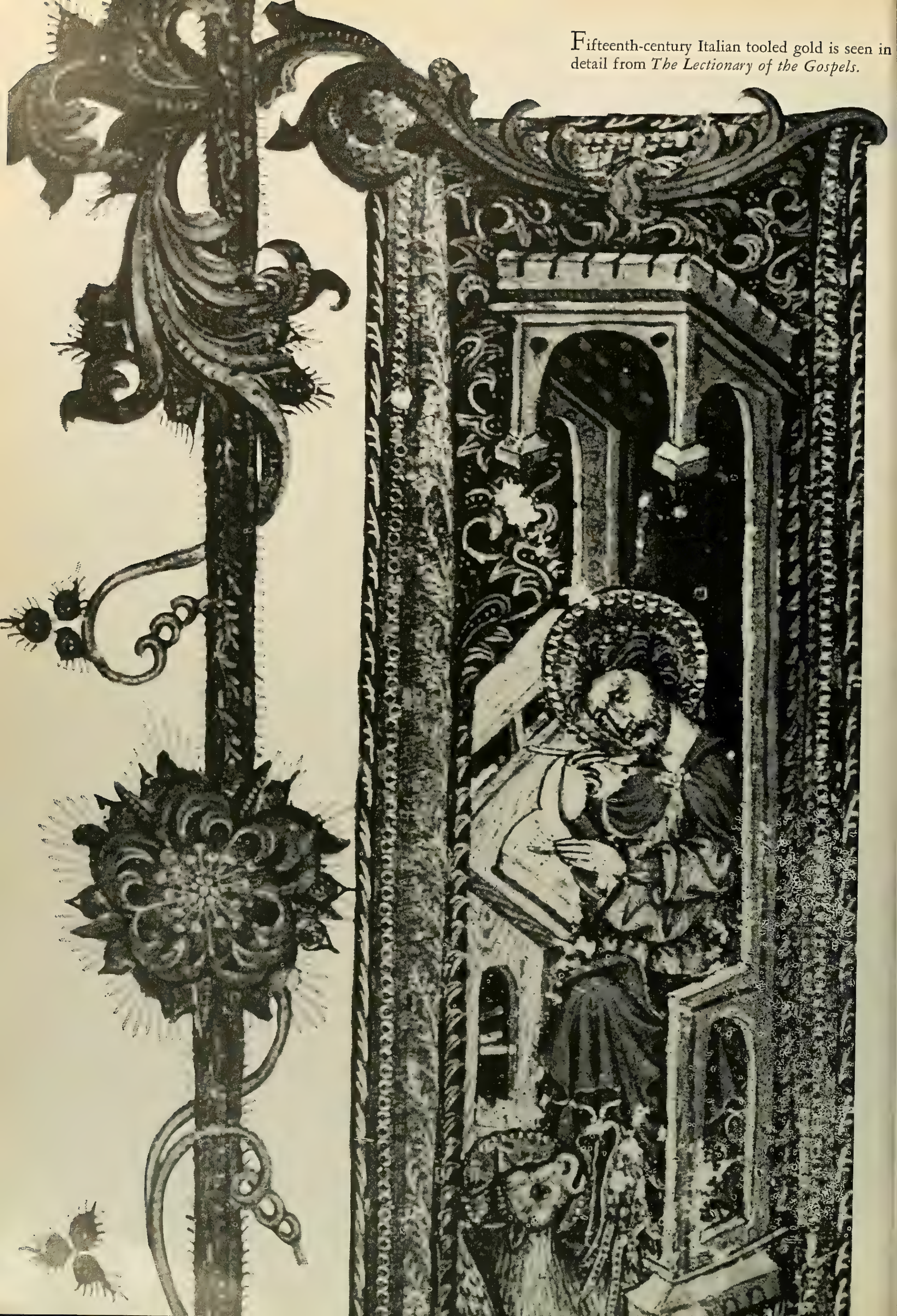
By night as well as by day, Dr. Jaeger studied the occupant of this Poor-will canyon. On one nocturnal visit, he found the dormant bird with one of its eyes wide open. From a distance of two inches, he shone the narrow beam of a flashlight directly into the pupil of the eye. Even this violent stimulus brought no response. The eye remained unblinking and unseeing. So deep was the torpor of the bird's hibernation that a violent storm of sleet and hail—although it left some of its feathers noticeably battered—failed to arouse it. By weighing the bird repeatedly during one season of dormancy, Dr. Jaeger found that, in spite of its extremely low rate of metabolism, its weight gradually but steadily lessened. Whether all Poor-wills hibernate or whether only some individuals do, the rest migrating south like other members of the goatsucker family, is still to be answered.

Everywhere we wandered that day, I unconsciously looked into small openings, peered into crevices, hoped in vain for another miracle, another Poor-will in the midst of hibernation. The chances against seeing it were astronomical. Dr. Jaeger noted that in more than forty years of wandering in the desert he had encountered only this single dormant bird. "It is doubtful," he added, "that I will see another." Only a very few persons ever encounter this ornithological rarity.

Seven years after Dr. Jaeger made his initial discovery, my wife and I were riding home at the end of our autumn trip across America. At Tucson, Arizona, we stopped to see Joseph Wood Krutch. Not long before, two workmen, while digging up an agave in the Silverbell Mountains, northwest of the city, had come upon a torpid Poor-will. When we saw it, it was resting on mesquite bark in a box set half underground and covered with a sheet of glass. The weather had turned unseasonably warm for January. The day before, the thermometer had risen to a high of 87° and, in this abnormal warmth, the Poor-will showed signs of awakening. From time to time, it would open its eyes sleepily. But soon the lids would droop, and it would fall once more into the deep stupor of its hibernation. Altogether, about thirty instances of hibernating Poor-wills have been recorded. Some of the birds have been found sleeping between stones in the open desert, others among the mountains. Most have been reported hibernating in clefts in rocks.

For a long time, Dr. Jaeger, Gregory Hitchcock, and I wandered about the Poor-will canyon—which, since then, appropriately has been set aside, with 160 surrounding acres, as the Edmund C. Jaeger Nature Sanctuary. When, at last, we descended and began crossing the expanse to break camp, I kept looking back to see, as long as possible, that spot, remarkable in its singular character and in its association with a dramatic discovery in natural history.

**Spiny outlines** of the cholla cactus are backlit by sun setting over the desert.



Fifteenth-century Italian tooled gold is seen in detail from *The Lectionary of the Gospels.*

# Base and Noble Metals in Illumination

By Shirley Alexander

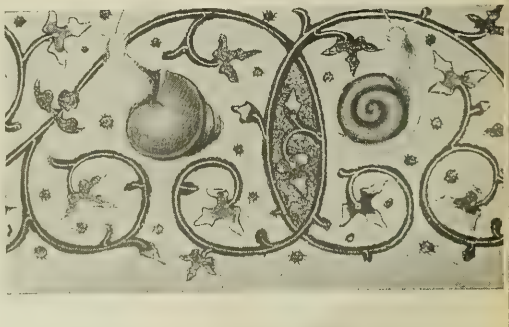
Numerous ancient literary sources testify to the special esteem that has always been accorded the manuscript written or illuminated with gold and silver. Throughout the period for which we have direct evidence of the production of illuminated manuscripts in Europe—that is, from the fourth to the sixteenth centuries A.D.—metal decoration at its most luxurious is found only in books for the wealthiest patrons. The epitome of magnificence was reached, according to the prevailing taste of the time, in the combination of gold and silver script on purple-stained parchment, in extensive backgrounds of highly burnished metal, or in the frequent use of small touches of metal paint for highlighting or accenting objects in a miniature.

The production of the finest metallic illumination was a lengthy process, from the purifying of the metal to its final burnishing on the parchment page. Our knowledge of the technical aspects is derived from a study of the manuscripts and from several medieval handbooks, which describe the methods and materials used for many arts and crafts, including illumination. Most of them contain recipes for the preparation and application not only of gold and silver but of numerous materials that were recommended in cases where the noble metals were not available. An examination of the manuscripts shows that some of these substitutes were successful to a surprising degree, especially in the fourteenth and fifteenth centuries.

From the evidence available to us concerning the decoration in premedieval books, metal appears to have been used in the earliest instances to represent objects actually made of metal, such as royal regalia or cuirasses; or, because of its lustrous surface, to give the appearance of reflected light even on objects that normally do not reflect light strongly, such as the feathers of a bird or the foliage of a tree. The gold for these early examples was refined, when necessary, by heating to a temperature sufficient to oxidize silver or other impurities. It was then beaten into metal leaf only a fraction of a millimeter thick, and cut to manageable shapes measuring a few centimeters on each side. From these small pieces of leaf, the shape required for a crown or belt was cut approximately to size, and the metal was attached to the papyrus or parchment or over a layer of paint by means of an adhesive—gum arabic or perhaps the white of an egg suitably beaten and mixed with water. As the metal leaf stuck only where the adhesive had been applied, the excess metal could be wiped away with a piece of soft cloth or a hare's foot.

Writing in metal ink on leather or parchment is also of early origin, predating the medieval period by nearly a millennium. For this purpose it was customary to use ink made by powdering the gold or silver and mixing it with a gum solution or similar medium. The earliest surviving formulas are almost entirely devoted to the methods that could be used to reduce gold to powdered form, as the malleability of the metal made the task particularly difficult. Today, gold powder is made from gold leaf ground with honey, a method whose origins are comparatively late. The earliest recipes suggest that the gold be amalgamated with mercury, the mercury evaporated off, and the embrittled metal ground with vinegar until it is clean. Other processes for brittling were advanced—quenching gold in water previously used for the repeated quenching of lead, for example. Alternatively, filed gold could

Margin decoration of a fifteenth-century French psalter shows the free use of burnished gold.



be ground to a powder with salt, a method designed to keep the gold particles separate from one another under the pressure of the grinder. An important group of recipes gives instructions for increasing the amount of the ink by the addition of less noble metals, such as copper or brass, or of non-metallic substances, such as the yellow pigment orpiment. According to the author of one such formula, the extenders were useful when the supply of gold ink was short or when there was a great deal to write. Gold or silver powder required far more metal for covering a given area of parchment than did metal leaf, so that the possession of a copy of the Homeric poems written in gold on the expensive purple parchment was much prized. The "royal purple" dye was obtained from the glands of certain shellfish, thousands of which were required to give a small amount of the material (NATURAL HISTORY, January, 1964). As an alternate, "dyer's moss," a lichen whose dye was extracted by boiling, was used. Josephus records that during the Ptolemaic period (*ca.* 323 to 30 B.C.) the Hebrew laws were written in gold on carefully prepared skins, and the invectives of early Christian fathers against the superfluous luxury of gold and purple prayer books are evidence of the frequency with which such books were produced.

Even at this early date, however, substitutes for metal were often employed, if we are to judge by the number of methods requiring their use. Gold substitutes included orpiment, saffron, tortoise or calf bile, with gum or wine used as the liquid medium. An interesting recipe of this type recommends a mixture of orpiment, saffron, and powdered glass, with egg white and gum as the medium, and a final burnishing with the tooth of a bear, boar, or wolf. In place of silver for writing, one recipe suggests the addition of vinegar to litharge and pigeon dung, which react to produce a lustrous, somewhat translucent, and viscous mixture of lead monoxide and potassium acetate. The product is too thick to use as an ink, but the recipe says this can be remedied by heating the pen over a flame before writing. If a metal pen is used, the heat melts the material sufficiently to write a few letters, although the substance may flow easily in hot weather.

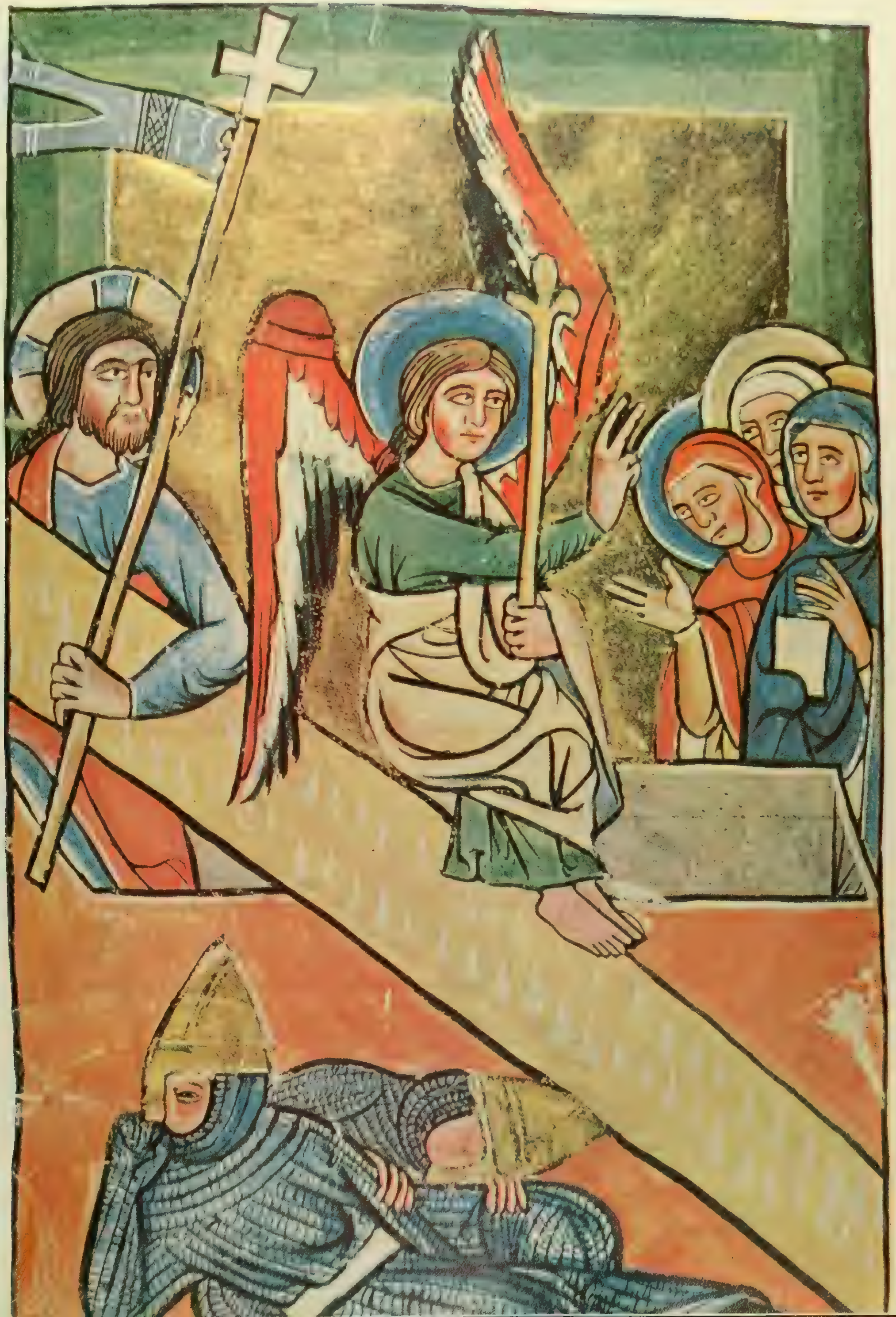
Metallic decoration was not generally used in early medieval illumination in Europe until the eighth century. By this time, its function of representing actual metal or reflected light in a naturalistic way had been superseded by a wholly decorative use of the material. Furthermore, the technique of using metal leaf had almost entirely disappeared, metal powder being substituted.

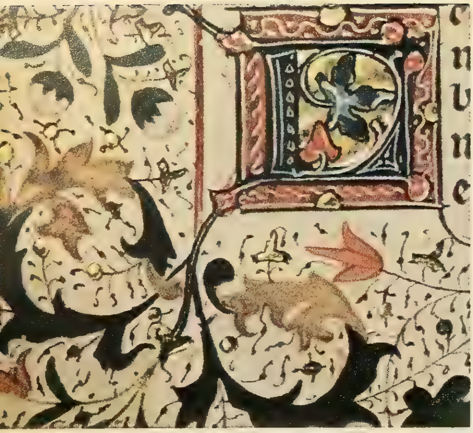
Religious scene with sections of burnished gold is in twelfth-century south German psalter.

The most sumptuous books still required the use of purple or dark-blue parchment, but most frequently only the written section of the page was dyed, and the margins were left the natural tone of the parchment. The purple dye was often of a redder hue than that used earlier, and in some instances blue paint was applied around the gold, instead of the gold being painted over the dyed area. Such characteristics indicate that ancient manuscripts were available for copying, but that an intimate knowledge of the materials and techniques was lacking. However, metal powder continued to be manufactured as before, and to be applied, like paint, directly to the parchment. By altering the shade of the metal through the addition of varying amounts of silver, copper, or lead, a contrast between different hues of gold could be achieved. This was consciously sought and employed with a subtlety of effect in such local Frankish schools of illumination as that at Tours.

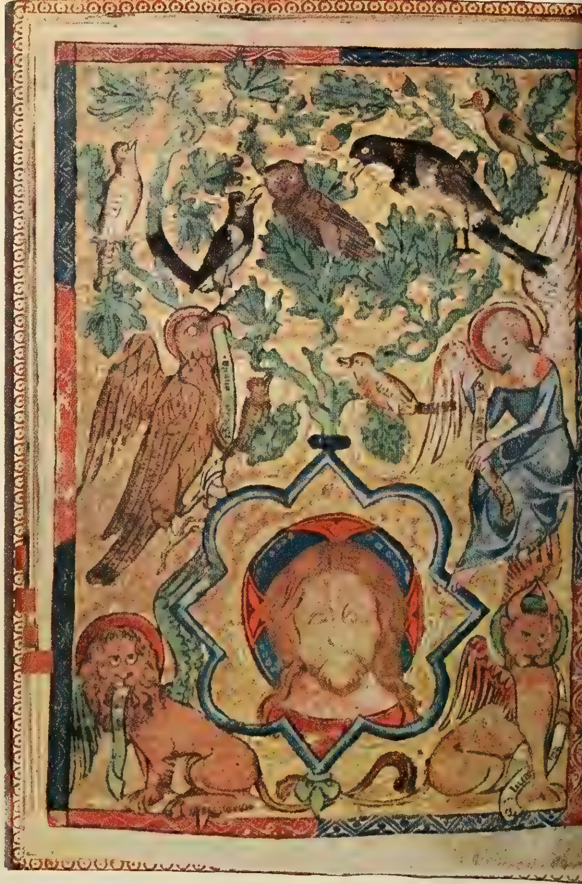
The formulas of the period are for the most part repetitions of earlier ones, and add little that is new to our knowledge of the techniques used. They suggest that the metal powder be burnished, and the manuscripts of the ninth and tenth centuries show that burnishing was the usual practice. A high polish could not be achieved, however, because the gold, if rubbed too hard, flaked off the surface of the parchment. Burnishing was carried out by means of a tooth, or with some smoothly polished mineral, such as hematite. The preparation of the burnisher is described in the treatises. The polishing of the surface was performed with a series of substances of increasing fineness, from emery to the hair side of cowskin.

Silver was commonly used in addition to gold, but it must have tarnished fairly soon after its application. Today, the silver of many manuscripts has tarnished and deteriorated in texture, and in several cases has either diffused through the parchment to cause a permanent stain on the reverse side or has eaten a hole completely through the parchment. The instability of silver was recognized at an early date, and the chief contribution of ninth- to tenth-century technical treatises is their advice to use tin in place of silver, or tin coated with saffron in place of gold. To what extent tin was actually

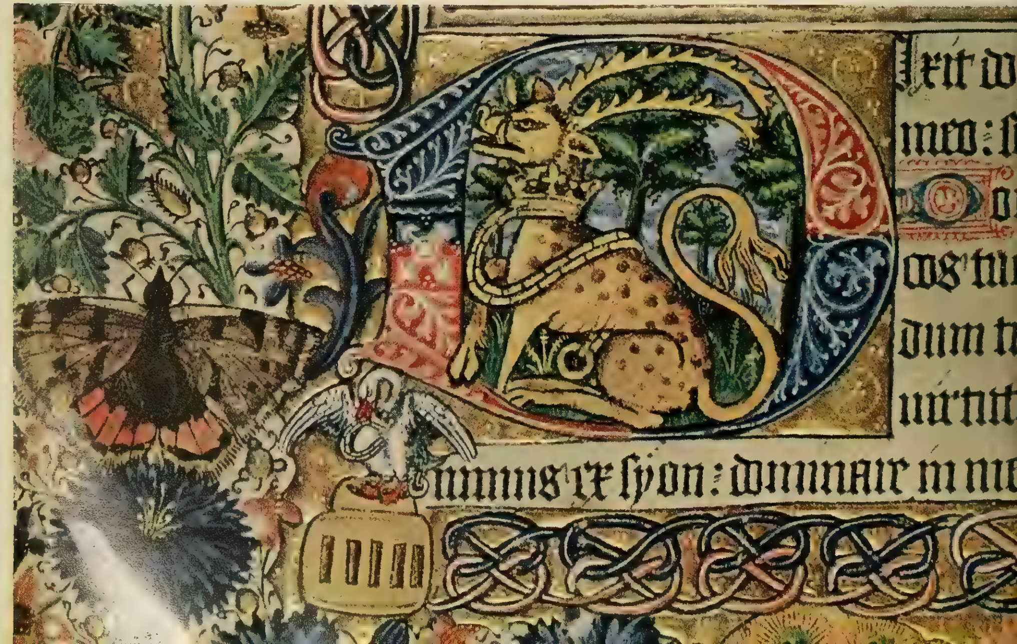


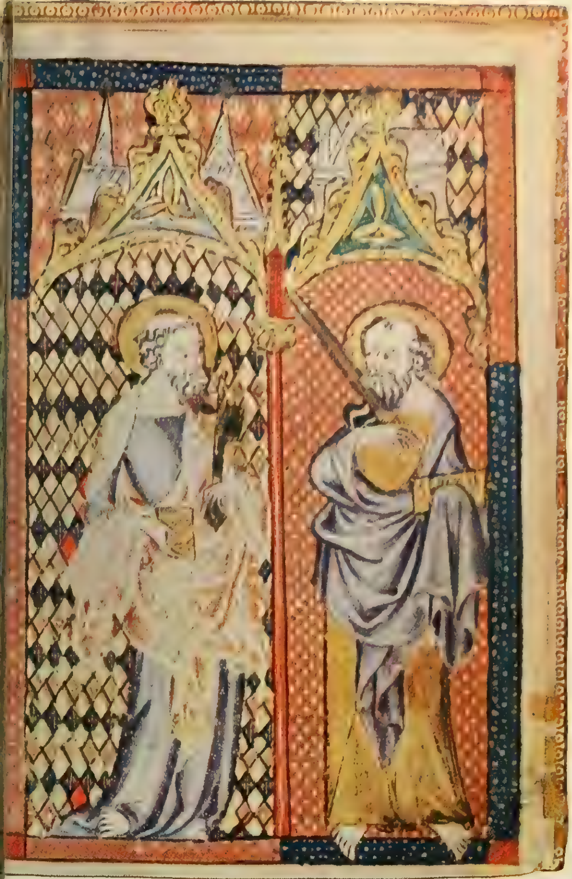


Initial letter and margin decoration show the combined use of gold and silver in the *Bible Historiale* by Petrus Comestor.



Flat and burnished gold were used in execution of fantastic beasts on this page of Wingfield *Psalter and Hours*.





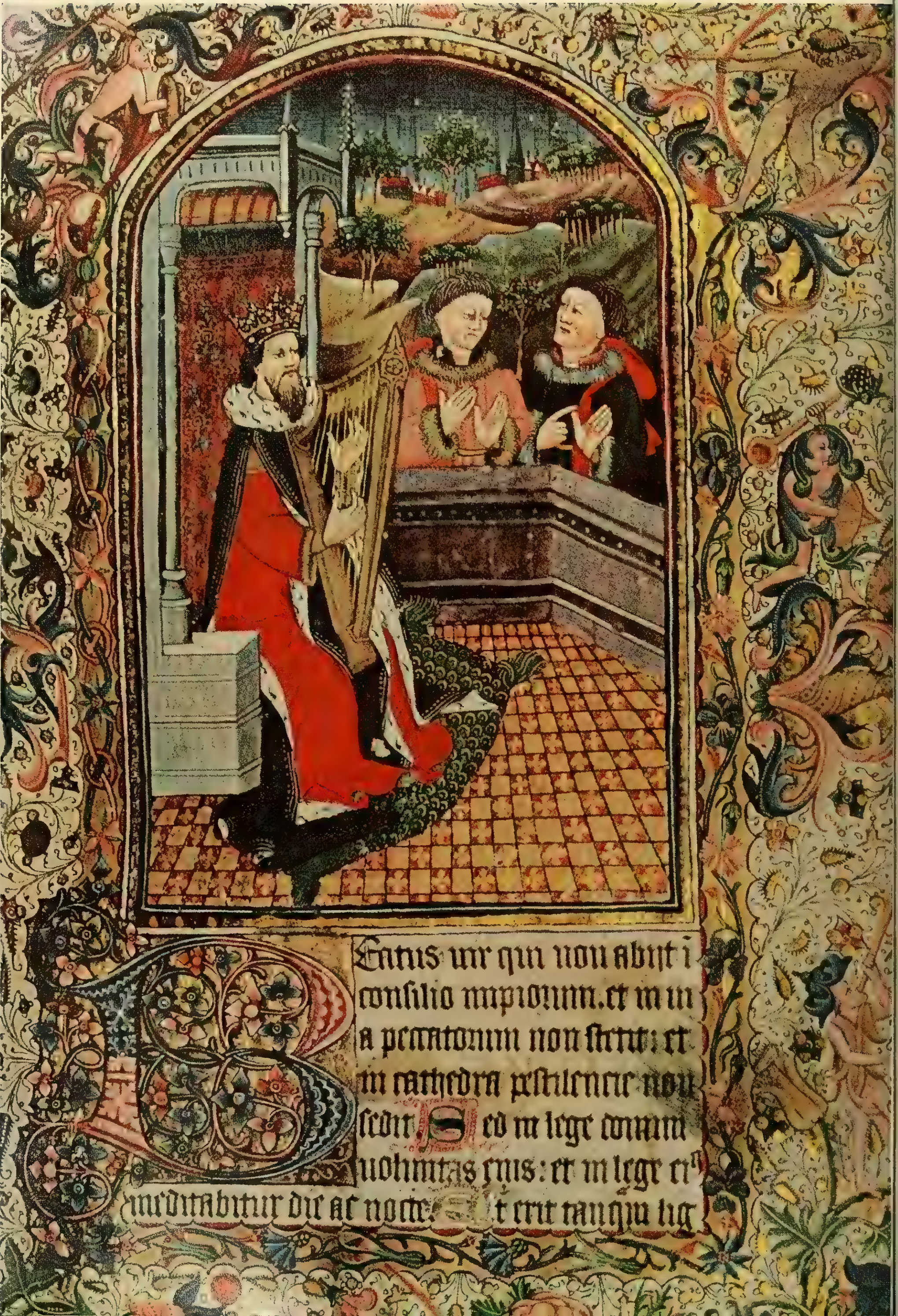
Two pages from this English *Book of Hours* show use of gold combined with color. Note right-hand page with diamond design.

used has not been determined: the manuscripts, with their now unrecognizable silver, suggest that it was not commonly employed. On the other hand, the suggestion for its use is met with increasingly in treatises after the tenth century, so that those manuscripts that retain bright, untarnished silver as part of their scheme of decoration may well turn out to be examples of the use of tin.

The eleventh century saw the beginnings of major changes in European illumination, as new ideas and influences penetrated to the West. The simultaneous shift in the conception of the role of metal decoration was part of a far-reaching movement, whose potentialities were to be fully realized in the wholly new techniques of metal application to manuscripts in the late twelfth century. Two well-known treatises, those of Eraclius and Theophilus, are representative of tenth- to twelfth-century artistic practices. They have one formula apiece for the manufacture of metal powder, a sharp decrease from the numerous repetitive recipes on the subject in earlier works, thereby bringing a new order and perspective into written techniques. Similarly, a new clarity is apparent in the metal decoration of manuscripts. The lavish use of gold and silver in Frankish manuscripts of the early ninth century, and imitation from antique manuscripts of methods of highlighting by means of metal, had been adopted by west German schools of illumination and developed, during the eleventh century, into a somewhat indiscriminate use of metal that had little reference to the special functions traditionally associated with the use of gold. In miniatures such as those of the Hitda Codex in Darmstadt, the identity of the metal is subordinated to the boldness of the design. Nevertheless, it was in German eleventh-century illumination that the new order and refinement first became apparent.

Under the influence of Byzantine painting, the south German school of Reichenau concentrated the gold in the background of the miniature, thus reducing the representation of architectural or landscape motifs to a minimum. The arrangement was adopted by other schools of illumination, but the change was gradual. The gold inched its way across eleventh-century backgrounds, but by the twelfth century the full gold background was the accepted method of procedure in much European illumination. Many south German manuscripts have pale-yellow backgrounds, achieved by mixing a fairly high proportion of silver or tin with the gold paint. This expedient does not appear to have been an attempt at economy so much as the adoption of a specific metal hue that blended perfectly with the delicate pastel shades of the painting.

However, the traditional gold paint of early medieval manuscripts was not as convenient for covering wide expanses of parchment as it was for adding touches of high light to a painted surface. Thus, it is not surprising to find that gold leaf entered into European illumination shortly after the introduction of the gold background. The renewed prominence of metal led to improved techniques of



Beatus vir qui non abiit i
consilio impiorum. et in vi
a peccatorum non stetit: et
in cathedra pestilencie non
sedit. Sed in lege domini
voluntas eius: et in lege eius
meditabitur die ac nocte. Et erit tanquam lig

application in order to give full value to the brilliance of which the material was capable. Where possible, the metal was attached in small squares or rectangles by means of a light adhesive, but where the shape was awkward, as in the outlining of figures, it was common to use small scraps of gold, often of irregular shape. A slight overlapping of the pieces, followed by careful burnishing, produced a smooth, continuous surface. But where the leaf was applied to the parchment without any preparatory underpainting, the possible amount of burnishing was limited, and the final appearance of the gold was at best a rather thin layer—bright, but not sparkling. With gold paint, it had been simple to build up several layers of metal or to use a thick paint, so that when burnished the gold looked like a solid metal backdrop against which the brilliantly painted figures gleamed with the richness of jewels.

To overcome this problem connected with metal leaf, a suitable support was provided that would raise the gold slightly from the surface of the parchment, and at the same time give a somewhat resilient surface against which the burnishing could be performed. Two methods were employed. The first was to paint a layer of a clay material, called bole, on the areas of the page to be gilded. Recipes from the fourteenth century onward record several reasons for using bole. Some considered it to be a suitable ground for subsequent burnishing of the gold, while others thought that it provided a satisfactory underpainting to enrich the metal, as the leaf was thin enough for its own tint to be affected by whatever was painted beneath it. Different types of bole were available. The red "Armenian" bole was considered to be the best, and appears to have been the most frequently used, although yellow, gray, and white varieties were not uncommon. Before the gold was applied over the bole on the parchment, the bole itself was burnished until it was perfectly smooth, for the gold leaf showed all the imperfections of the surface upon which it was laid.

The second method was perhaps the more common during the later phase of illumination. Several thin layers of gesso, similar to that used for the priming of wooden panel paintings, were applied to the parchment in those places where burnished gold was required. When the gesso was thoroughly dry, and had been smoothed to perfection, a wash of bole was painted over it, an adhesive was added, and the gold leaf laid on top while the adhesive was still tacky. The skill required by the artist at this stage is described in a recipe that advises the gilder to work away from currents of air—including his own breath—while transporting the metal leaf from the pad on which it had been cut to shape to its destination on the page. The leaf was so thin that the slightest disturbance of the air caused it to blow away or to become a crumpled mass, difficult to restore to its former flat state. After a few hours, burnishing was begun, gently at first, but with increasing energy, until the gold shone with a brilliance not obtainable by any of the previous methods. As the gilding was the first part of the miniature to be completed, before the pigments were applied, there was no fear that the painting would be damaged by the burnisher. The rough edges of the gold could be concealed by pigment where they were adjacent to the painted area; otherwise it was usual to outline the metal with red.

The gold background, whether plain or tooled with a series of cross-hatchings, circles, or rosettes, was characteristic of twelfth- and thirteenth-century illumination, and was used in some localities as late as the fifteenth century. If we are to judge by the formulas, the methods of applying and burnishing the metal remained unchanged until the end of illumination, although the appearance of the gold on the parchment page underwent several transformations. In the fourteenth century, the plain background became a checkered pattern of small gold squares or lozenges, each one fully burnished, alternating with similar shapes using different pigments. Or the ground might first be painted with pigment, with a foliate pattern in gold superimposed on it. The trend toward the rendering of natural shapes caused foliage and animal forms to encroach with increasing insistence on the gold. At first the burnished metal was transferred to details within the miniature—belts or collars or hems of garments—but as the fourteenth century progressed, it became clear that the magnificent brilliance of raised and burnished gold was an encumbrance to the painter of naturalistic scenes. With increasing frequency gold was relegated to margins, initials, and the backgrounds of initials, amid highly naturalistic renderings of flowers, birds, and butterflies. It may be thought that this was the logical time for the quiet demise of metal usage in miniatures, but the best was yet to come: the ever resourceful gilder found new and more splendid uses for his material.

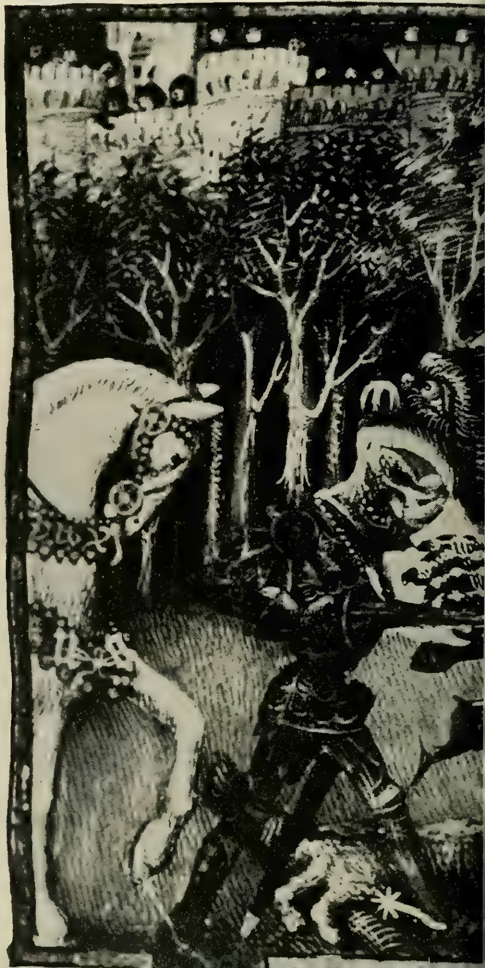
Wingfield *Psalter and Hours* is outstanding as a work of two different artists of same period.

Flat or unburnished metal leaf, whose earliest surviving use can be traced to painted Egyptian papyri, returned to miniature painting when the highly polished metal no longer met the requirements of the painter. At first, the two types of leaf were used in the same miniature, with a fine contrast of surface texture, but gradually the flat gold predominated, because it could be used without embarrassment as the natural method of representing a rich fabric, a halo, or a sword blade. Black pigment could be applied over its surface to depict the outlines of folds in drapery, or to separate the sections of a suit of mail.

New uses were found for silver in the representation of daylight shining through a lattice window, light reflecting from a choppy sea, or moonlight gleaming on the water of a fountain.

The fifteenth century was the final and most creative phase of the technique of metal application. In addition to the polished and flat metal leaf described above, metal powder made a forceful return at this time. Although predominantly used to highlight drapery or foliage, silver was also employed as a variant of white or gray, and gold as a variant of yellow. Thus in the fifteenth century, it was possible to find, on one manuscript page, burnished and tooled gold leaf in marginal decoration, with flat metal leaf and metal powder in the miniature. The painter had made an effective compromise between the essentially medieval connotations of metal decoration and the contemporary naturalism that required landscapes and detailed studies of natural forms. In their most imaginative use, gold and silver were employed either purely decoratively or naturalistically within the same manuscript, and a different technique was used for each different purpose. Experiments were made in reproducing various textures by means of metal. Fur, for instance, could be approximated by attaching finely crumpled gold leaf to the parchment, creating an uneven surface; rich drapery could be enhanced by applying a wash of paint over a ground of gold. A curious virtuosity is found in fifteenth-century Flemish manuscripts, in which painted gold grounds were of frequent use in miniature and marginal decoration. In some cases, the amount of gold powder in the medium was so slight that the effect of gold was entirely lost, and the backgrounds resemble a dull yellow ocher pigment to the unaided eye. Similarly in contemporary French work, gold leaf in marginal decoration is of such unusual transparency that the grains of gold appear to have separated, giving the appearance of powdered metal. A low-power microscope is necessary to detect such detail.

In the earliest recipe books, as already noted, substitutes for the precious metals are of common occurrence, used when metal leaf was too expensive or too scarce. The situation was quite different in the fifteenth century when substitutes were used in their own right, side by side with gold and silver, providing striking variations of surface appearance. At the same time, the unaided eye accepts many of them as metallic substances. Two types are found, those that are of small but discrete particle size and evidently meant to represent metal powder, and those that are smooth and shiny and resemble burnished metal leaf. Without an analysis of each substance, it is not possible to state which materials were used. Fifteenth-century recipes de-

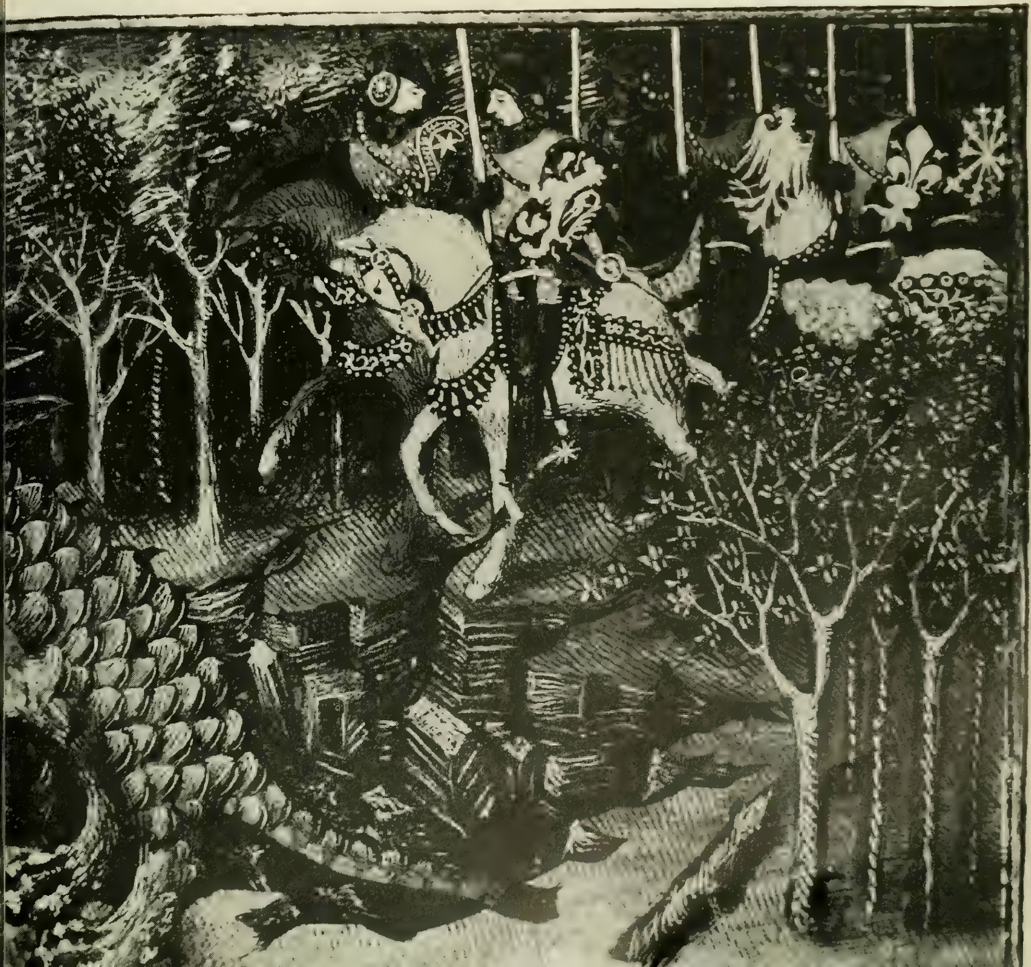


scribing the first type—powdered metal substitutes—say that the white should be removed from an egg and mercury poured into the shell with the yolk. The egg is then sealed and put under a hen for a month. The egg yolk hardens to a certain extent and, through contact with the mercury, turns to dull yellow ocher. When the yolk is powdered and mixed with a gum solution, a fairly good substitute for gold is obtained. Alternatively, marcasite, a disulphide of iron that resembles iron pyrite or dull brass in surface appearance, was ground to a powder and mixed with gum. The usual red bole was applied to the parchment under the material, although burnishing was, of course, not practicable.

The second type of substitute, that for metal leaf, has several recommendations in the formulas, notably distilled goat's horn, or the coating of nonlustrous materials with certain types of varnish, egg white, or gum. For the most part, such substitutes were used in place of the flat metal rather than the raised and burnished metal leaf, and were treated in exactly the same way as the flat gold; details were painted over them, or they were covered with a wash of pigment.

As one of the most characteristic aspects of medieval illumination, the technique of metal application to parchment is the one craft that best displays the skill, versatility, and ingenuity of the medieval artist. It may be that St. Jerome considered golden books to be burdensome extravaganza, but for us, the predilection of the Middle Ages for magnificence in its material and in its craftsmanship is a source of deep interest and admiration.

Gold powder was indiscriminately used in fifteenth century for highlighting and metallic effects.



thoſe that grow in the Fieldes and Medowes, and then of the reſt in their order.

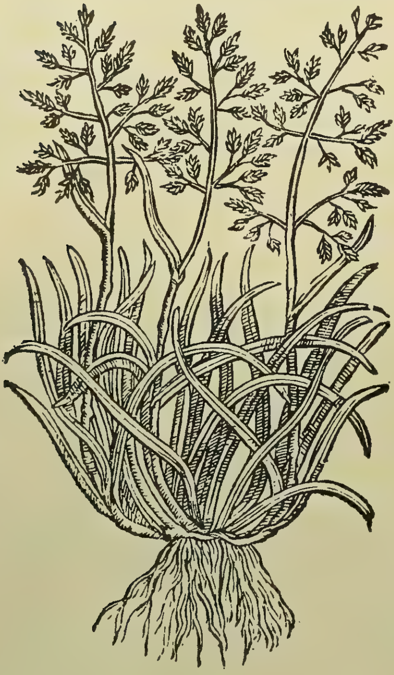
1. *Gramen pratenſe paniculatum molle.* The ſoft Medow tufted Graſſe.

This ſoft Medow Graſſe, hath ſundry long and ſomewhat broad ſoft or woolly Graſſe-like leaves, riſing from a ſmall tuft of ſhort white fibres, and from among the leaves riſe up a ſtalke, two or three, about a cubit high, with ſome few leaves upon it, and at the toppe breaketh forth a ſoft woolly ſpiked head, much divided, whoſe bloomings are reddiſh.

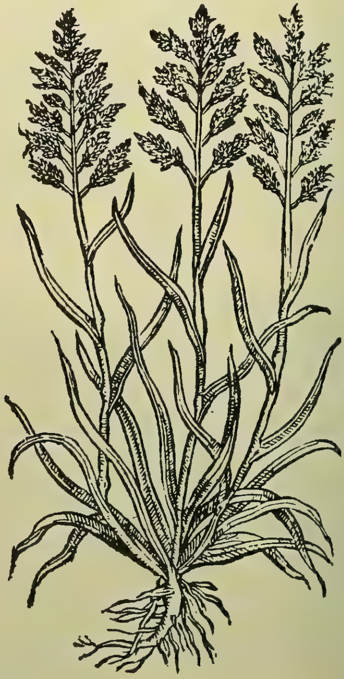
2. *Gramen paniculatum Germanicum odoratum.* Sweete Dutch Graſſe with a tufted head.

The roote of this Graſſe doth creepe in the ground, being white, and full of joynts, ſhooting out fibres at every

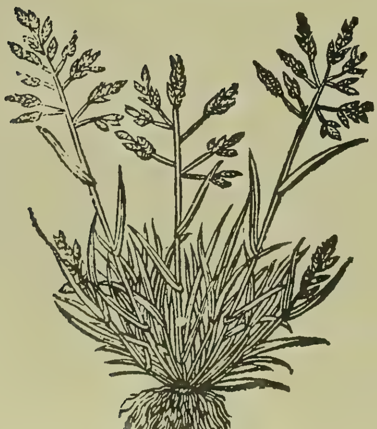
4. *Gramen pratenſe vulgatius majus.*
The greater ordinary Medow Graſſe.



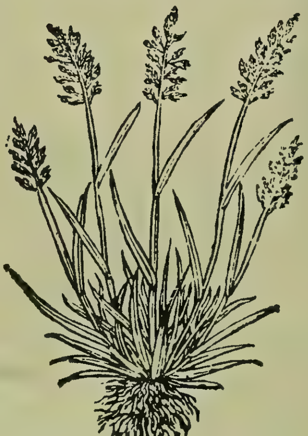
4. *Gramen pratenſe minus.*
The leſſer tufted Medow Graſſe.



4. *Gramen pratenſe minimum album.*
The leaſt white Medow Graſſe.



4. *Gramen pratenſe minimum rubrum.*
The leaſt red Medow Graſſe.



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# THE MIGRATION OF A PLANT

## Kentucky Bluegrass Followed Settlers of New World

by ROBERT W. SCHERY

Kentucky bluegrass, *Poa pratensis*, has made its mark as one of the most widespread and "successful" of the higher plants. Although man has in many instances upset ecological balances, Kentucky bluegrass has managed to adapt to changing conditions, rather than to die out or linger on precariously in isolated ecological niches. Indeed, throughout history, Kentucky bluegrass has increasingly enhanced its world position, for it followed man as he felled trees and turned soil.

It is a true grass, a member of the Gramineae, one of the plant kingdom's most useful families. We all depend upon grasses—for grains that make bread, for forage that nurtures our livestock, for the cover that holds our soil, for sugar, for certain essential oils and medicinals, and even for beer. Traditionally, Kentucky bluegrass has fallen into a subfamily and tribe named for the fescues, Festuceae. Certainly the fescues are similar to the bluegrasses, *Poa*, in many ways, and are well placed side by side in classification, just as they are companions in the better lawn seed mixtures. Both behave similarly in a lawn and respond to the same general regimen of handling, perhaps a further indication of relationship. Bromes and other forage grasses are also of this tribe.

According to modernists, the Festuceae, embracing the fescues, ryegrasses, orchard-grasses, etc., as well as bluegrass, are of the "large chromosome" type, usually with a base number of seven. (Base number means the lowest denominator that is possible to cover the hereditary complement.)

In comparison with other grasses, Kentucky bluegrass was traditionally regarded as having many primitive characteristics; its tribe was thought to be among the least specialized, which may help explain its remarkable adaptability. But the whole business of primitiveness is being questioned these days, for a major attribute of Kentucky bluegrass is that its seed mostly forms without being fertilized by the male cell. Except for a small percentage of instances in which there is true sexual crossing, the seed of Kentucky bluegrass is identical with the mother plant on which it is borne. This type of asexual reproduction, known as apomixis, is analogous to cuttings or live starts in other grasses and horticultural plants. Apomixis has been regarded as a relatively advanced character, and often is associated with polyploidy, the doubling of the chromosomes (in the case of Kentucky bluegrass, repeated and seemingly irregular duplication). Apomixis is characteristic of many of the world's most widespread and successful plants, including various lawn nuisances such as the dandelion.

**Woodcuts** from 1640 Parkinson herbal refer to bluegrass as "Medow Grasse."

For the bluegrass seed industry, apomixis is a boon; it is necessary to find only one plant of unusually desirable features, and propagate from it by seed. This has been the chief means of discovering new bluegrass varieties, rather than the more involved crossing of isolated parent plants. By the same token, the system imposes limitations, and it becomes difficult to cross bluegrasses of two different types in order to combine desirable features of both parents in the offspring.

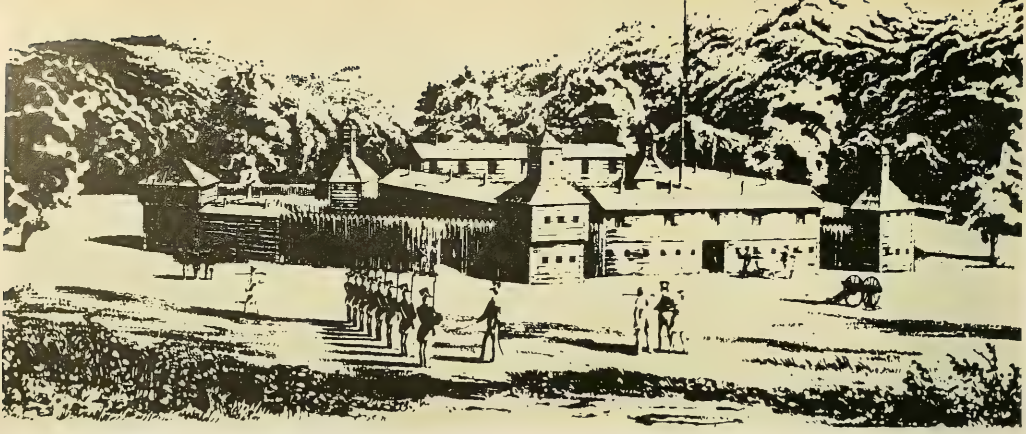
Not much is really known about the hereditary make-up of Kentucky bluegrass other than that it is mixed and has an extremely wide range of chromosome numbers—ranging from less than fifty to more than two hundred in some polyploids. With such a diverse genetic complex to choose from, there is almost no need for the plant breeder to attempt sexual crossing. Those instances in which sexual crossing has been successful have not resulted in producing a bluegrass superior to those chosen from nature.

One of the original antecedents of Kentucky bluegrass may have been diploid *Poa pratensis*, native to southeastern Europe, with a chromosome number of possibly only fourteen. In its subsequent peregrinations there has occurred a grand genetic mix-up, perhaps with other bluegrasses, and certainly involving a great deal of duplication and variation in chromosome sets. The resulting complex—the present-day *Poa pratensis*—may represent a synthesis of several species.

Bluegrass has conquered the hills and the uplands in moist temperate climates over most of the globe. Heat, rather than cold, seems to be its nemesis, for it is found within the Arctic Circle and was planted and survived in the Antarctic during recent geophysical year investigations. But it persists in tropical environments only at high elevations. In the United States it is not permanent south of Tennessee in the east or below northern Arizona in the west, although some ecotypes hang on in the shade as far south as the Gulf of Mexico. It may, however, be a prize component of annual winter seeding mixtures for golf greens and lawns throughout the south.

This, then, is a "cool-weather" grass, as distinguished from "warm-weather" grasses such as Bermuda, *Zoysia*, Bahia, and other southern types. While the latter flourish in the heat of summer, bluegrass physiology is adjusted to a lower optimum temperature. In fact, its internal mechanisms seem to suffer when temperatures remain persistently above about 85° F. Catabolic losses, through stepped up respiration, mount rapidly at higher temperatures, while food making (photosynthesis) does not increase proportionately, and may even slow down. The net result is an "operating loss" for bluegrass during hot weather. Of course, if this deficit persists for any great length of time, stored energy is exhausted, and the plant dies.

In those regions or seasons where temperatures range between 55° and 80° F., Kentucky bluegrass is at its glorious best. The food build-up from photosynthesis exceeds its dissipation, and there is abundant thickening, quick revival, and beautiful color. Growth slows when temperatures ap-



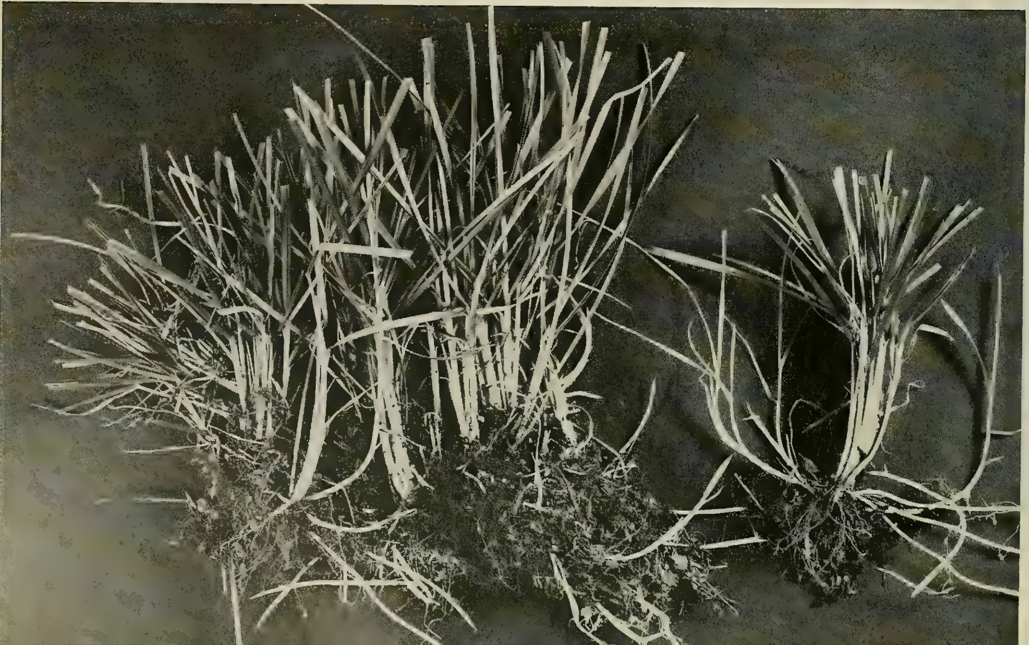
**Ohio's** Ft. Washington is thought to be early site of bluegrass in America.

proach freezing, but the health of the grass is in no way impaired. Kentucky bluegrass can stand crisp freezes without harm and with scant blemishing; in middle latitudes it is not until after Christmas that its sods begin to show the effects of winter.

The grass is primarily spread by underground runners called rhizomes, which weave a firm sod. If the stembuds at the crown of the plant grow upward instead of sideways, they form new shoots (culms) called tillers, which thicken the stand of grass. This is characteristic of growth during autumn, when, incidentally, the leaves are short and bend low in response to the declining day length. Rhizomes may be produced almost any time the growing weather is favorable, particularly with plants that are not crowded (sod-bound) and are rooted in loose soil. Rhizome spread contrasts with aboveground pre-emption by crabgrass, one of the chief competitors of bluegrass in the lawn. Crabgrass is an annual, sprouting from seed as the weather warms, then spreading rampantly by trailing runners called stolons.

With "wild" bluegrass, enough rain to keep the grass green during the good growing weather of autumn augurs well for a fine seed crop the following June. Many fat shoots will initiate a primordial inflorescence, or seed head, about Christmastime, as temperatures drop to near freezing. Short day length is also necessary; plants kept in a lighted greenhouse will not set seed. In spring, each culm that is to become a seed head carries characteristic, stubby "flag" leaves with a bluish sheen; the seed stalk becomes tough, and for a couple of weeks during late spring it is difficult to mow neatly. Each culm that bears a seed head will die, to be replaced by side

**Sample** from lawn shows underground rhizomes, by which the grass spreads.



tillers. Even the healthiest of bluegrass will experience a temporary downturn in early summer, and the regaining of its resplendency depends largely upon how quickly and fully the new tillers take over. Obviously, tiller resurrection will be more adequate in favorable climates with coolish nights.

There will be some differences in growth pattern depending upon the variety or selection, but research has indicated the marvelous plasticity of natural Kentucky bluegrass. Plants brought together from north and south, east and west, dissimilar in their appearance where they grew, all gradually mold to an essentially identical norm when grown side by side. The reason for this adaptability is not altogether known; probably it is because of the tremendous genetic reservoir that gives bluegrass a broad base compatible with most environments. As we saw earlier, there may be duplication to two hundred chromosomes from a base number of only seven.

As evidenced by the scatter diagrams on page 44, Kentucky bluegrass populations differ as the plant extends its range. In this country it seems to have behaved according to Vavilov's hypothesis that greatest variation occurs at the center of origin and dispersal. It looks as if the lower Midwest, Kentucky in particular, where bluegrass was known early and widely planted, served as the seat of dispersal. Even today, Kentucky seems to carry the largest bluegrass gene pool of any area. From this center, particularly successful hereditary combinations appear to have migrated rapidly outward, especially pushing northwest. Collections of specimens from North Dakota and Minnesota exhibit a narrower range of variation and express a more characteristic phenotype (physical appearance) than in Kentucky, where no single expression seems to have dominated the population.

This, then, is Kentucky bluegrass as we have it today—one of the most nutritious pasture grasses, an excellent soil builder, and the most widely used quality lawn grass. How came this change from diploid vagrant to polyploid world colonist, from unnoticed adventive to pampered lawn grass?

It is probably a good assumption that Kentucky bluegrass originated in Europe or the Near East, where semidomestication and the chance for intercrossings leading to polyploidy have been so notable with many cultivated plants. The early Greeks had a word for it, although it merely signified "fodder herb" or "forage grass." This "pua" of Euripides and Eubulus has been verified as a floral constituent of the Peloponnesus, where the climatic cycle has a summer moisture deficit similar to that of our Midwest. It is also identified by Professor G. Hausman, Director of the Experiment Station of Field and Pasture Crops at Milan, as a "grass found in every part of Italy, especially the mountain districts." What is probably *Poa pratensis* flourished in southeastern Europe in pre-Christian times.

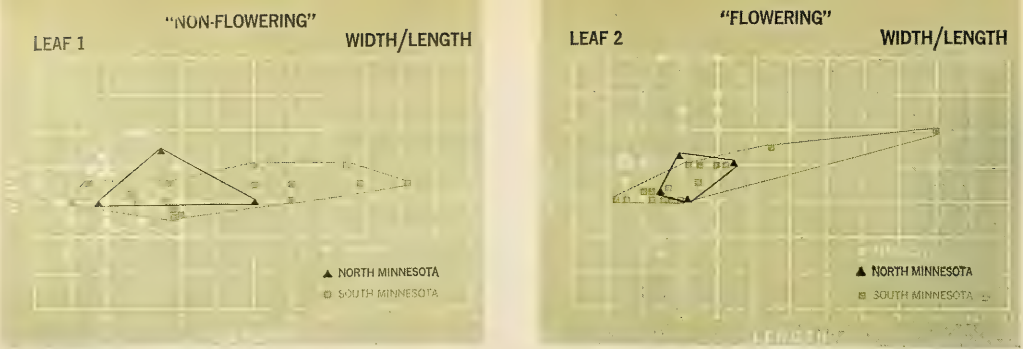
No doubt the Romans grazed their chargers on bluegrass as their legions marched on Heidelberg and Paris. Garibaldi's palace at Innsbruck was described as having a lovely lawn, probably of bluegrass. The herbalists of the Middle Ages made recognizable woodcuts of bluegrass, which they called "meadow grass" or "June grass" in the polynomial descriptions prevailing before Linnaeus. They verify cognizance of bluegrass by the Greeks, mentioning its medicinal properties as prescribed in ancient Greek tomes. By the time botanical identification had become a science, bluegrass was known throughout the continent. It was Linnaeus, in his *Species plantarum*, who gave it the *Poa pratensis* designation—*Poa* after the old Greek; *pratensis* meaning "of the meadow." Today, in all its variations, it is universally known as *Poa pratensis*, although through the years scores of common names have been accorded it.

At the time of the discovery of the New World, *Poa pratensis* was widely spread throughout northern Europe, even though given scant attention in an age when pastures were taken for granted and cultivated lawns scarcely yet "invented," although formal estate gardens were the vogue. Was bluegrass also in Asia, the North Atlantic islands, in North America itself? We can only guess. Circumstantial evidence, as we shall see, suggests that it was not. Glacier-capped islands of the North Atlantic make poor stepping stones, and there are no herbarium specimens to indicate that bluegrass came from the inhospitable wastes of Siberia across the Bering Sea to Alaska, and thence into the western United States. That it was not in North America when the first colonists landed at Jamestown is indicated, too, by the fact that it was never given an Indian prefix in the colonial records, a custom with newly discovered plants such as Indian corn (maize). Most likely it was merely a chance passenger on the early ships bringing colonists and cattle to the new land—taken for granted, if it was noticed at all. There are no exact records, but then who would report to Raleigh about grass while exploring a new continent beset with "treasure" and mystery?

**Map** traces possible migration routes from Jamestown (1) to colonies (2); and southward into Mississippi Valley (3) to Illinois (4) and Kentucky (5).

Yet the early records of the Jamestown colony, and of subsequent settlements in eastern North America, leave no doubt that bluegrass could have gained a foothold. There are many mentions of tilled lands and gardens, prime habitat for bluegrass. Thomas Harriot's *A Brief and True Report of the New Found Land of Virginia*, 1588, includes a notation that "we found topsoil deeper, we saw there more and larger fields and finer grass, as good as any in England . . . more English cattle should be transported; likewise our varieties of fruits, roots and herbs . . . some of them have already been sown and have grown well. . . ."

Other reports of "English grass," as bluegrass mixed with white clover was termed in those days, attest to



SCATTER diagrams of flowering and non-flowering plants of Kentucky and Minnesota indicate that grass with long, narrow blades is most successful in migrating northward from center of dispersal. Measurements are in 1/32 inch.

familiarity that implies Old World origin. Captain John Smith, in 1629, reported "James Towne is yet their chief seate most of the wood destroyed, little corne there planted, but all converted into pasture and gardens; wherein doth grow all manner of herbs and roots we have in England in abundance and as good grasse as can be. . . ." William Penn told of sowing English grass, and Thomas Jefferson mentions it repeatedly. By Revolutionary times there were many names for *Poa pratensis*—at least twenty-seven have been counted—including "blue grass," so called by Thomas Jefferson in his *Notes on Virginia,* 1782. Other names were green grass, Junegrass, meadow-grass, speargrass, Rhode Island grass, and greensward grass.

Trained botanists did not set foot in America until the mid-eighteenth century. Peter Kalm observed bluegrass in 1749, indubitably *Poa pratensis,* abundant along the St. Lawrence. Gronovius listed it—no mistaking the identity—in his *Flora virginica* of 1762. And there are reports of "seas of grass," of uncertain botanical definition, greeting Boone when he first left the Yadkin Valley of North Carolina for his explorations into Virginia's western territory, known as Caintuck. Indeed, Caintuck, eventually Kentucky, is said to have meant "among the meadows" in Indian language.

It is not known how bluegrass first reached Kentucky. One report, difficult to verify, mentions an Irishman, John Findley, who paddled down the Ohio River from Pennsylvania, and then up the Kentucky River to trade with the Shawnee in 1752. Findley is said to have built a cabin and stockade, and to have scattered "English hay" that had been packed around his cargo. Was this the first introduction of the grass that was to be named for the eventual state of Kentucky? A John Finley—perhaps the same person—is also reported to have engaged Daniel Boone to act as his guide across the old "warrior's path" from the Blue Ridge into Kentucky, in 1769. Might this, or other Boone expeditions, have carried bluegrass seed into the state, either by chance or by intent?

While these speculations may be worth considering, the most likely explanation is that *Poa pratensis,* noted so widely in French Canada by botanist Peter Kalm in 1749, may have been carried down into the Illinois country by French missionaries in the early seventeenth century, and from there spread along the waterways, bypassing the mountains, to what is now Kentucky. The missionaries may have intentionally brought in bluegrass seed as they were wont to do with seeds of other plants. Marquette and La Salle had opened missions in Illinois as early as 1672 and 1682, and there were settlements at Kaskaskia, Illinois, by 1700, and at Vincennes on the Wabash River by 1702, a half century ahead of John Findley's Indian trade in the same general area. Both settlements were flourishing when visited by Charlevoix in 1721. It is likely that bluegrass was poised just north of Kentucky, or introduced there, before Boone visited the land he opened.

Interesting support of the belief that bluegrass may have naturalized in the Midwest is given by letters written in 1818 by an Illinois resident named Birkbek: "Where the little caravans have encamped as they crossed the prairies, and have given their cattle hay made of these perennial grasses, there remains everafter a spot of green turf for the instruction and encouragement of future improvers—a fact which, I think, is conclusive against the prevailing notion that the natural grasses, as they are called, are the best adapted to soil and climate." It is well accepted that the North American prairies were entirely of grasses that turn brown in winter; Birkbek's observation suggests that Old World introductions were present where travelers encamped.

There are those who claim that the bluegrass that made Kentucky famous actually came from southern Indiana, brought back by the returning volunteers who fought with Harrison at the Battle of Tippecanoe in 1811. It was reported that the soldiers discovered the superior qualities of bluegrass and, when they returned home, sowed the seed on limestone soil. A present-day farmer, C. Henry Baum, Jr., of West

Lebanon, Indiana, maintains that General Harrison camped in his grove at both start and finish of the Tippecanoe expedition. He believes that the bluegrass seed in question was gathered from his farm. Similar claims are made for a spot five miles north of Crawfordsville, where a Federal penitentiary now stands near Terre Haute (the seed reportedly sent to Henry Clay in Kentucky by his brother-in-law, General Harrison). Another Indiana resident, Mayme Jacobs, corroborates: "My great-grandfather, John Hamilton, was a captain with General William Henry Harrison in his raid on Tecumseh, and my mother heard great-grandfather Hamilton tell of being one of those who carried the bluegrass seed to Kentucky."

Although admitting that bluegrass came to the United States with the Jamestown and Williamsburg settlers, still others have claimed that it was not in Kentucky until after 1812. Rather, they say, the cavalry with Anthony Wayne spread bluegrass at the encampments on the Pickaway Plains in Ohio, where it prospered, and from which seed was gathered and taken to the Lexington area of Kentucky. About 1822, a man named Renick is said to have gathered the seed and delivered it to the farm of his brother, who settled near Lexington. This is possible, but most likely it is not the first introduction into Kentucky, where bluegrass had probably flourished on the rich phosphatic soils for a long time. In any event, there, near Lexington, the English grass, meadow-grass, speargrass, or what you will, became Kentucky bluegrass.

*Poa pratensis* was not known by the name Kentucky bluegrass until after 1833. Neither Elliot's *Botany of South Carolina and Georgia*, 1812; Muhlenberg's *Catalog of the Plants of North America*, 1813; nor Short's *Catalog of the Plants and Ferns of Kentucky*, 1833, mention it by that name, although the species is invariably listed.

But by 1840 there are references such as this by Bidwell and Falconer: "the limestone region of Kentucky was famous in the West as the center of prosperous and contented agriculture. Its bluegrass pastures were widely known. . . ." Well's *Yearbook of Agriculture*, 1855-6, mentions: "*Poa pratensis:* smooth-stalked meadow grass. In Kentucky it is called Kentucky bluegrass . . . succeeds far better in Kentucky . . . than it does in any part of Europe, where it is native." And Charles Flint, *Grasses and Forage Plants*, 1858, notes: "In Kentucky it is universally known as bluegrass, and elsewhere frequently called Kentucky bluegrass. . . ."

Thus did Kentucky bluegrass gradually come to be known for the state. It remains resplendent today over the fields and pastures of north-central Kentucky, one of the finest and most beautiful agricultural areas in the world, renowned especially as the breeding ground for some of the fastest thoroughbred horses. To a large extent, the growing of bluegrass for seed is now carried on farther west. But the tradition lingers in Kentucky, where a way of life has been based upon grassland farming.

Not only in Kentucky, but throughout the United States, bluegrass has played an important role in suburbs and agricultural areas. Dr. E. N. Fergus of the University of Kentucky points out: "With little assistance it achieved wide distinction for pasture and turf. One has only to imagine—if he can—home lawns, parks, playgrounds, air fields, golf courses, roadsides, cemetaries, campuses and other institutional grounds without their carpets of bluegrass to appreciate in some degree the significance of this grass in our living."

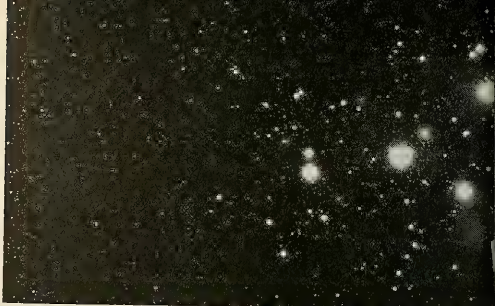
Perhaps the most eloquent eulogist was John James Ingalls, senator from Kansas, 1873-1891, who delivered a speech, "In Praise of Bluegrass," to Congress. Ingalls concluded: "Grass feeds the ox: the ox nourishes man; man dies and goes to grass again; so the tide of life, with everlasting repetition, in continuous circles, moves endlessly on and upward, and in more senses than one, all flesh is grass. But all flesh is not bluegrass. If it were, the devil's occupation would be gone."

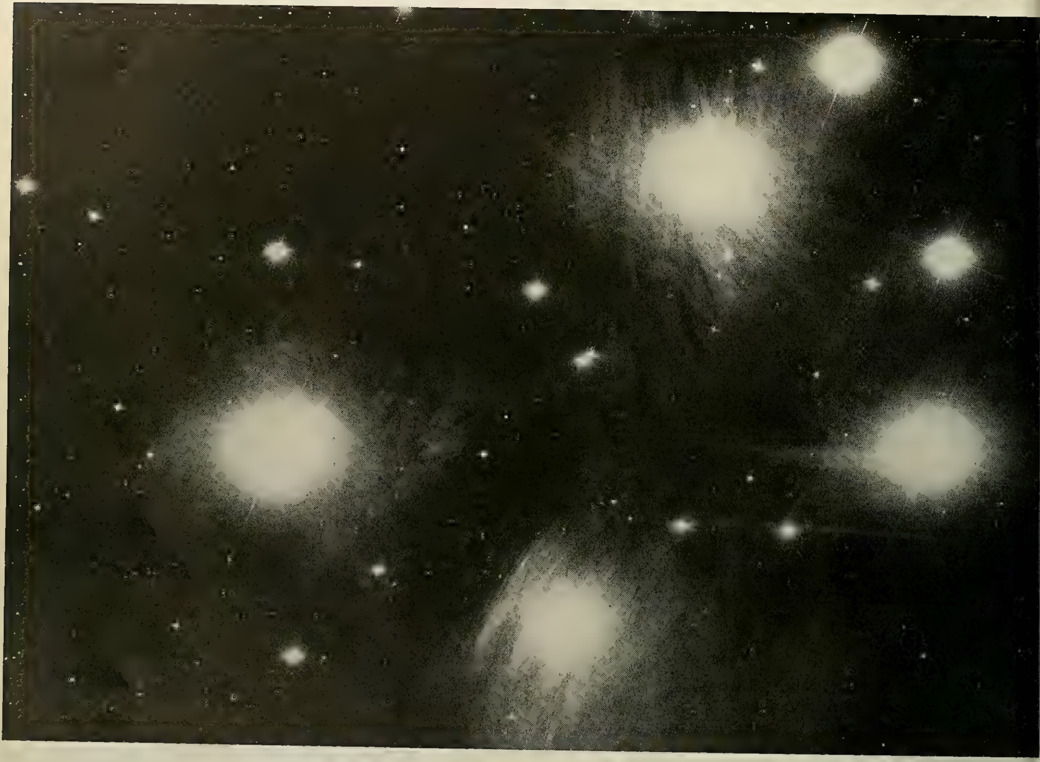
**STRIPPING machines comb seed heads from stalks. Seeds will then be cured.**

# SKY REPORTER

## The Pleiades form is analyzed

By Thomas D. Nicholson





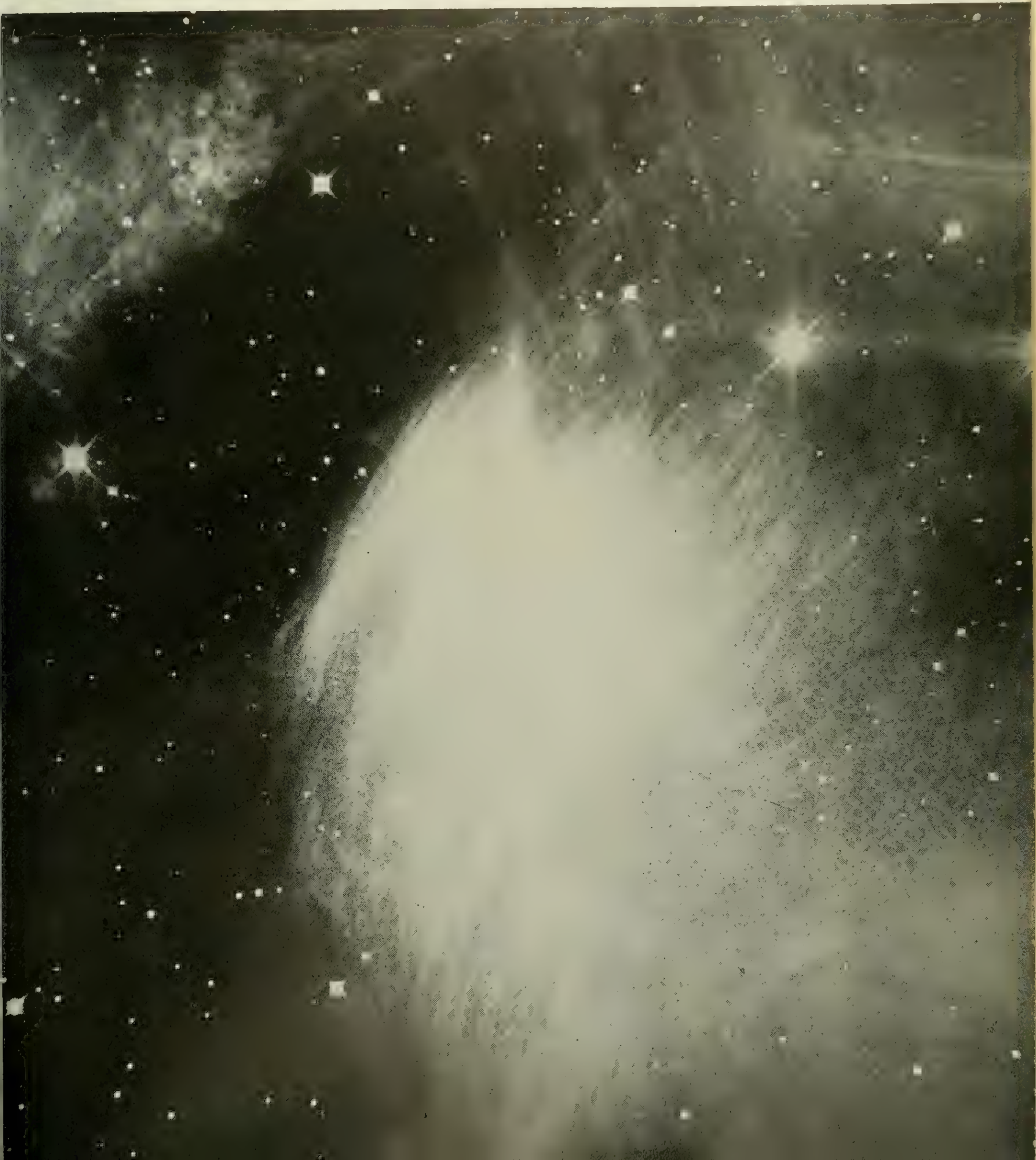
The cluster of faint stars known as the Seven Sisters, or the Pleiades, is a familiar feature of the evening sky from early November until March. On December nights it rises just before sunset and is high in the eastern sky by the end of twilight. Located in the northwestern corner of the constellation Taurus, the Bull, the Pleiades is a harbinger of the winter sky.

On a clear, dark night, the Pleiades looks like a compact but hazy group of faint stars. When the sky is less clear, or when bright moonlight interferes, it may be difficult to make out the individual stars of the cluster, but it still may appear as a faint cloud of light. The brightness of the nearly full moon on the evenings of December 7 and 8 this year, for example, may all but hide the constellation, which will be just to the left of the moon on the 7th, to the right and above it on the following evening.

The position of the Pleiades is such that it is visible from every inhabited part of the world. This may be why it appears in legends from all parts of the globe and from all periods of history. Its name originated in Greek mythology. The Pleiads were the seven daughters of Atlas, who held up the heavens, and the nymph Pleione; nine of the brightest stars in the group are named after the members of this mythological family. The daughters are Alcyone, Asterope, Celaeno, Electra, Maia, Merope, and Taygete—hence the constellation's alternate name of Seven Sisters. In other cultures, the Pleiades is known as Seven Doves, Seven Brothers, Seven Maidens, and The Hen and Seven Chicks. The number seven is particularly interesting because today most persons can see only six stars in the group without the aid of a telescope.

However, more than six stars actually are visible. The

COMPLETE CONFIGURATION of the Pleiades, in Taurus, *left*, shows faint nebulosity around Merope (*arrow*). The group of stars is seen as an open cluster formation, *below left*. Merope, *below*, is visible enveloped in its beautiful nebula.



most easily seen are, from left to right across the top of the group, Atlas, Alcyone, Maia, and Taygete, and, from left to right below, Merope and Electra. Actually nine stars in the group are fifth magnitude or brighter, and thus well within naked-eye visibility on a clear, dark night for persons with good vision. One difficulty in seeing more than six stars is that they are so close together that it is hard for the eye to resolve them. But some persons can clearly see Pleione, just above Atlas. And some claim to be able to see both Celaeno, between Taygete and Electra on the right side of the group, and Asterope, just above Maia.

An interesting sidelight to the number of visible stars is the legend of a "lost" Pleiad. In the Greek myth, one sister made herself invisible out of shame for having loved a mortal. This and other legends have given rise to a popular modern myth that there were seven bright stars in the group during some period of past history. It has even been suggested that Pleione, which has undergone slight changes in brightness and spectrum in recent years, may have once been much brighter. However, there is nothing to support this thesis. The Pleiades have been essentially unchanged within the nearly three thousand years for which we have records of the appearance of the sky.

As interesting as it has been in star lore and legend, the constellation is perhaps of more interest as an object of investigation for astronomers, who were surprised to find so many visible stars gathered into so small a region of the sky. Simply the appearance of the visible stars in the Pleiades suggested that it could be a physically associated group in space, and not a random collection of bright stars. Proof of the physical relation is found in the stars' motions. Careful studies, dating back to a pioneering work by the German astronomer F. W. Bessel, in 1840, show that they are moving together in space in the same direction and at the same speed. A comparison of recent photographic measurements with Bessel's catalogue shows that the stars of the Pleiades all have a proper motion (a motion across the line of sight) of about 5.5 seconds of arc per century. In addition, all the stars in the group have a radial velocity (receding from the earth along the line of sight) of about 4.3 miles per second, as shown by the shift of absorption lines in their spectra. The motions shared by the stars are so nearly identical that studies over more than a century have failed to reveal any evidence of the dispersion of the cluster.

This common motion provides, in turn, the key to the identification of the stars that are members of the group and to the group's total size. Some of the faint stars in and near the bright members of the Pleiades share its motion, and are known to be members of the cluster; those that depart, even slightly, from the motions common to the group are known to be simply foreground or background stars. An early study by the Swiss-American astronomer R. J. Trumpler, in 1921, identified 246 certain members of the Pleiades among the brighter stars of the region. Other investigators have suggested far greater numbers. For example, the Danish astronomer E. Hertzsprung reported a photographic survey in 1947 in which he identified over 3,000 stars brighter than seventeenth magnitude as other members of the group.

The distance to the Pleiades is most readily determined from a study of the color-luminosity relation of its stars ("Sky Reporter," August-September, October, 1965). A more direct method of finding distances to a moving cluster is based upon the principles of perspective, but because the motions of its members are so nearly parallel, a convergent or divergent point is difficult to determine. But when the relation between color and brightness for the stars of a cluster is compared to the color-luminosity relation for stars of known distance, the absolute magnitude and the distance modulus (difference between absolute and apparent magnitude) of its stars can be determined. In this way, the Pleiades is found to be about 400 light-years away.

Dr. Nicholson, the regular author of this column, is also Chairman of the American Museum-Hayden Planetarium.

The Pleiades appears to have a diameter in space of about 70 light-years. This has been calculated by using a distance of 400 light-years and 5 degrees of arc as the apparent radius of the cluster, based on the most distant stars observed within it. Star density near the center is about 100 times greater than that in the sun's vicinity. Were we at the center of the cluster, where the more massive and brighter of its stars are concentrated, our sky would contain more than 100 stars of the first magnitude or brighter.

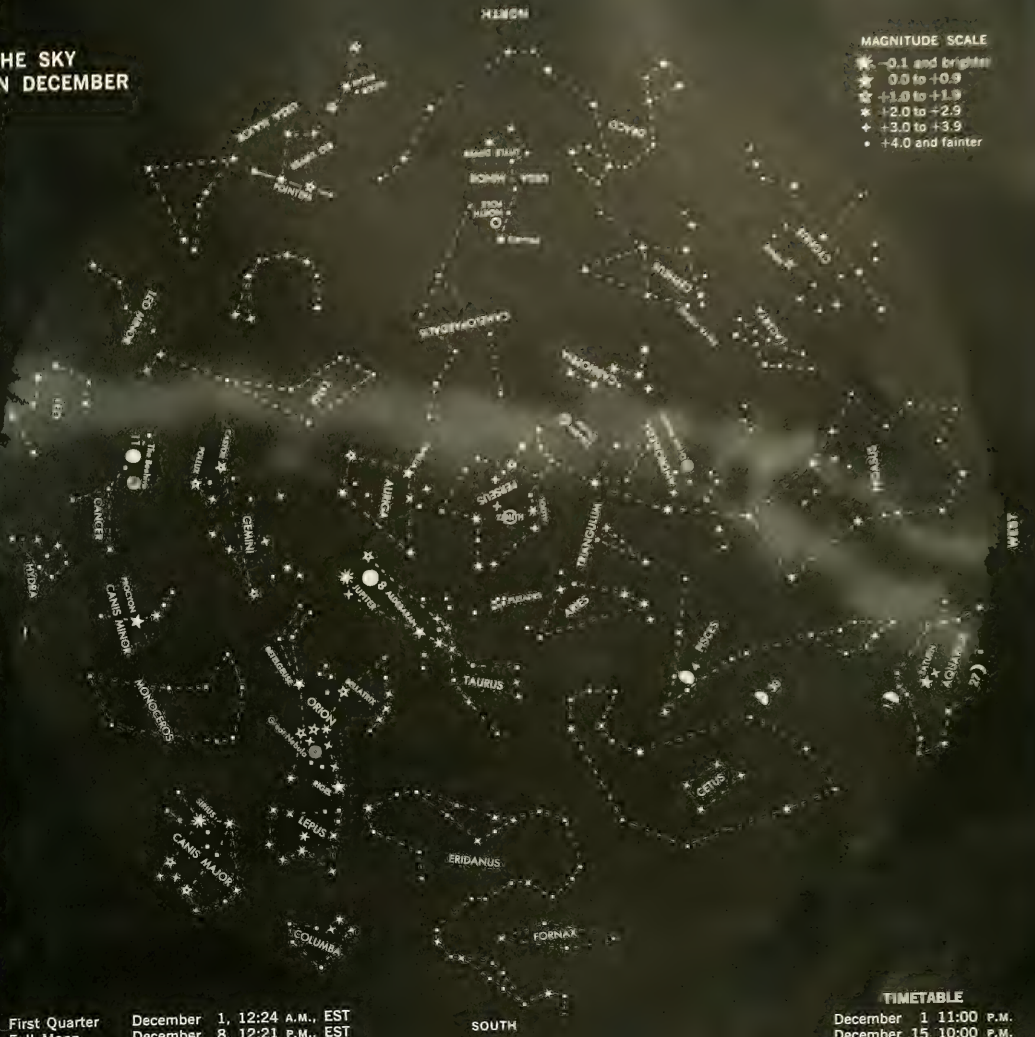
The apparent concentration of the brighter and more massive stars toward the center of the Pleiades was investigated recently (1961) by the American astronomer D. N. Limber. He concluded that at the time the cluster was formed the stars were distributed differently, and took on their present arrangement as a result of the cluster's gradual relaxation as its less massive stars moved farther away from the center of the system's mass. Limber estimated that this relaxation period took about 80 million years. This is close to the age estimate of the Pleiades—about 60 million years—based on the color-luminosity relation.

Remarkable as the visual appearance of the cluster may be, the photographic appearance is even more impressive. Even short-period exposures show that the stars are surrounded by glowing clouds of nebulous material. In longer exposures, in which the light of the faintly glowing surrounding matter is allowed to accumulate, the stars' nebulosities produce a photograph of startling beauty. Each bright star in the cluster appears to be embedded in softly flowing wisps of bright matter. Most beautiful of all is the nebula surrounding and near the star Merope.

Color photographs of the nebulosity show that it is predominantly bluish, consistent with its nature as a reflection nebula. The brightness is simply starlight reflected from the clouds of gas and dust in which the relatively hot, blue stars of the cluster are embedded. Small grains of interstellar matter—mostly frozen compounds of hydrogen, which predominate in this interstellar cloud—scatter blue light more effectively than other colors.

Photographs, however, do not indicate the total mass of dust and gas that occupies the interstellar regions of the cluster. Radio observations have suggested that the interstellar medium has a mass equal to about 470 times the mass of the sun. In comparison, the stars of the cluster have been estimated to have a total mass of about 760 solar masses (most are much less massive than the sun). Thus the interstellar gas and dust should make up about 40 per cent of the total mass of the Pleiades. Clearly, there is still sufficient matter left to allow the stellar formation process to continue within the Pleiades, even though the initial process that produced its massive bright blue stars may actually have terminated as long as 60 million years ago.

# THE SKY IN DECEMBER


NORTH
MAGNITUDE SCALE
-0.1 and brighter
0.0 to +0.9
+1.0 to +1.9
+2.0 to +2.9
+3.0 to +3.9
+4.0 and fainter
URSA MAJOR
POINTERS
DRACO
URSA MINOR
LITTLE DIPPER
NORTH POLE
LEO MINOR
CAMELOPARDALIS
CASSIOPEIA
CEPHEUS
CYGNUS
LYRA
LEO
LYNX
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The Beehive
CASTOR
POLLUX
CANCER
GEMINI
AURIGA
PERSEUS
ANDROMEDA
PEGASUS
WEST
HYDRA
PROCYON
CANIS MINOR
8
JUPITER
ALDEBARAN
PLEIADES
TRIANGULUM
ARIES
PISCES
TAURUS
SATURN
AQUARIUS
27
MONOCEROS
BETELGEUSE
BELLATRIX
ORION
Great Nebula
RIGEL
CETUS
SIRIUS
CANIS MAJOR
LEPUS
ERIDANUS
COLUMBA
FORNAX
SOUTH

| | |
|---|---|
| First Quarter | December 1, 12:24 A.M., EST |
| Full Moon | December 8, 12:21 P.M., EST |
| Last Quarter | December 15, 4:52 A.M., EST |
| New Moon | December 22, 4:03 P.M., EST |
| First Quarter | December 30, 8:46 P.M., EST |

**TIMETABLE**

| | |
|---|---|
| December 1 | 11:00 P.M. |
| December 15 | 10:00 P.M. |
| December 31 | 9:00 P.M. |

(Local Mean Time)

December 2: Mercury, passing between the earth and the sun, is at inferior conjunction at 11:00 P.M., EST.

December 8: A partial solar eclipse occurs on the moon today; the result on earth will be a penumbral lunar eclipse, but it cannot be seen in the United States.

December 8-9: Jupiter, magnitude —2.3, can be seen to the left of the moon on the evening of the 8th, to the right on the evening of the 9th.

December 12: Mercury, which has been moving retrograde while passing between earth and sun, resumes direct motion.

December 13: The Geminid meteors reach maximum this morning, usually about 50 meteors per hour. The view will be cut by competition from the moonlight.

December 18: Jupiter is at opposition at 4:00 A.M., EST. Exactly halfway round the sky from the sun, it rises at sunset and sets at sunrise.

December 21: Venus begins to diminish in brightness from what is now its greatest magnitude, —4.4.

Mercury is at greatest westerly elongation; as a morning star it rises in the east just before dawn for a few mornings before and after this date. It should be visible a little to the right and above the crescent moon. On the mornings of the 21st and 22nd, the reddish star Antares, in Scorpius, may help locate Mercury.

As the sun arrives at the winter solstice, 8:41 P.M., EST, winter begins in the Northern Hemisphere.

December 22: Maximum of the Ursid meteor shower occurs today. The hourly rate is 15, with no moon interference.

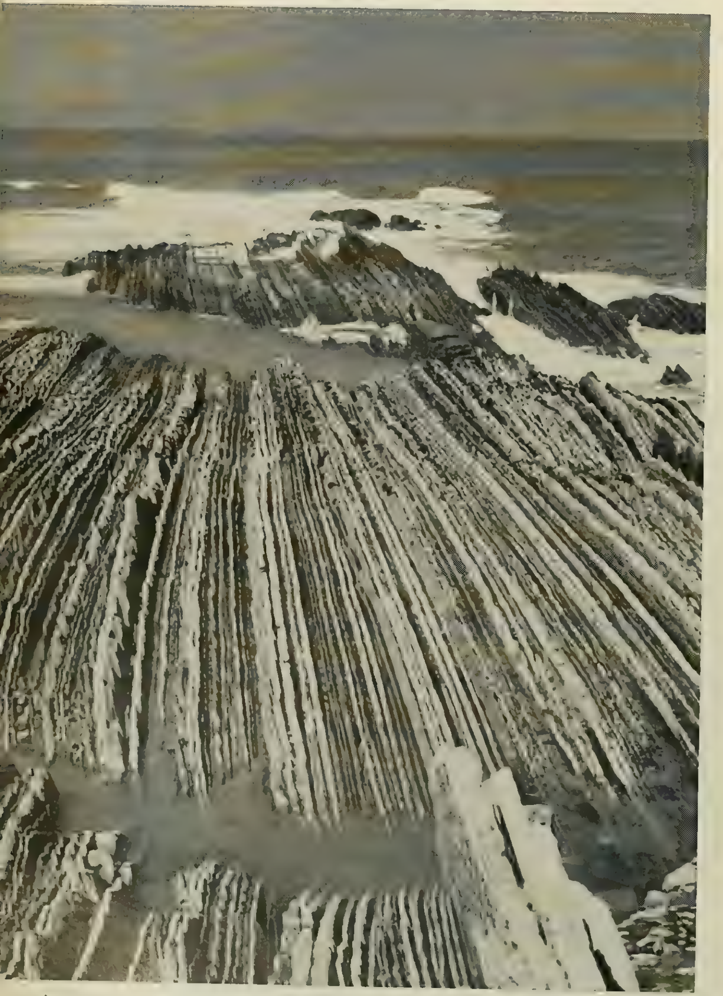
December 25: Venus and the moon should present a pretty scene in the Christmas night sky. Venus, still brilliant, will be in the southwest after sundown, standing almost directly above the slender crescent moon.

December 28: Saturn and the moon are in conjunction about noon, EST. They will be fairly close in the evening sky of the 27th and the 28th.

All Month: Venus still dominates the evening sky, although appearing lower in the sky toward month's end. Saturn is in the south to southwestern sky during the first half of the night, and Jupiter is visible throughout the night. Mercury remains the morning star during the last half of the month.

# Sedimentary Origins of Rock Layering

### by PAUL EDWIN POTTER



ALTERNATING BEDS of limestone, shale, and sandstone form a wave-cut bench on coast of Spain. Each sandstone bed was left by a single turbidity current.

SANDSTONES, limestones, shales, sands, and muds are abundant at the earth's surface and, as a result, nearly everyone has seen at least one significant feature of sedimentary rocks—layering. Whether the outcrop is a large cliff in an arid region, a wave-cut bench along a rocky coastline, a spectacular new highway cut, or a modest exposure along a small stream, prominent layering is almost always a clear indication of a bed's sedimentary origin—its deposition by moving water, air, or occasionally ice.

The study of layering, also called bedding or stratification, is part of the study of primary sedimentary structures, which are formed during the deposition of a sediment. Secondary structures, on the other hand, are formed after deposition. Primary structures are geologically instantaneous, many forming in a matter of hours or days, while secondary structures form at much slower rates—from ten thousand to several million years. Both structures are found in most sedimentary rocks, and because they can readily be seen without the help of complicated instruments, their study is as old as the study of geology itself.

The velocities of water and air currents are variable, and the deposition of sand, silt, or mud in a river or in a lake, on a beach or in an ocean, usually occurs erratically, rather than at a uniform rate. Fast, strong currents transport more and larger particles than do slow currents. If we consider hypothetically that currents are only of two strengths, slow and fast, instead of having a wide, continuous range of velocity as they have in reality, then we can see that fluctuations of velocity from fast to slow would result in alternating layers of muds and sands over a period of time. Current pulsations such as these, with a wide velocity range, are caused by changing amounts of water discharge in a stream, tides along the shore, variable winds over a shallow body of water, or turbulence created by water passing over rough surface.

WHEN the geologist is examining an outcrop, he sees mainly the products of sedimentation and, from this evidence, can infer a bed's origin. A single bed, or sedimentation unit, has been defined as that thickness of sediment deposited under essentially constant physical conditions (fast- or slow-moving currents, for example).

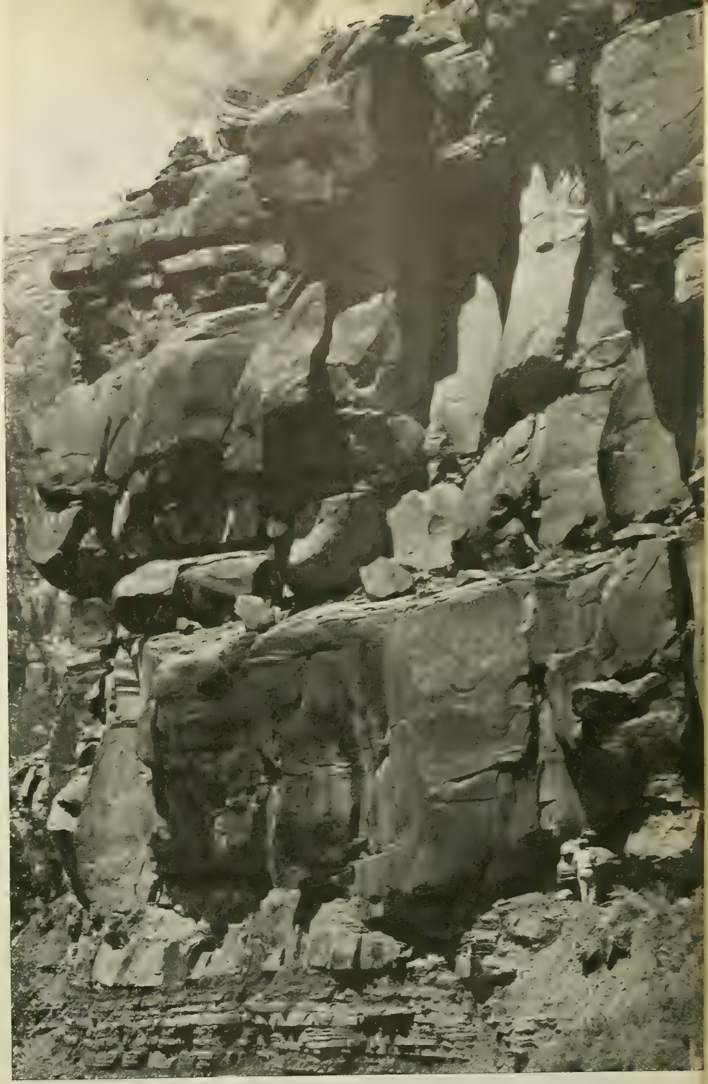
The qualification "essentially" allows for minor variations in current velocity, which may cause internal laminations within a bed or internal variations of grain size. Beds are separated by bedding planes, which mark a minor pause in deposition and reveal a variety of grain size and mineral composition. On the basis of geologic origin, then, sedimentary structures are: (1) hydraulic structures formed by water currents; (2) animal structures caused by the tracks, trails, and burrows of animals that once lived on the sea bottom; (3) structures formed by slumping or sinking; and (4) structures that are the results of escaping fluid or gas. Some structures, of course, are a mixture of more than one origin, and in studying them in the field, it is easier to divide them into these four groups: external shape, internal organization, bedding plane features, and disturbed and deformed bedding.

THE first impression one obtains of an outcrop is largely determined by the character of its layering. Are the beds thick or thin? Do they have much or little lateral continuity? Are they of uniform thickness, or are thick and thin layers interstratified? As these questions suggest, the fundamental properties of a bed are its thickness and lateral continuity—in short, its external geometry.

The study of the external shape of beds has many practical applications. For example, thick, uniform beds generally make a better reservoir for gas or oil—one with more permeability between wells—than a reservoir with irregular and discontinuous beds. This is true primarily because laterally uniform beds transmit fluid more easily. Highway construction gives another example. Building a highway along a hillside is generally difficult if the bedrock consists of thin-bedded sandstones or limestones interstratified with shale. Interstratified shales are unstable and tend to slide downhill, while bedrock of thick, massive sandstone makes a solid foundation.

The factors responsible for the shapes of individual beds are not fully understood, but there are fairly well-established geologic interpretations for some types of sedimentation. A long, even, uniform bed of sand, interstratified with mud, was probably deposited by a single, debris-laden current running downhill along an ocean bottom; this is called a turbidity current flow. In the Sigsbee Deep of the Gulf of Mexico, a single bed of turbidite origin has been cored over an area of some 4,000 square miles. Thin, regular, sandy beds exposed at Zumaya in northwest Spain are also good examples (*see photograph, left*). Turbidity currents are geologically instantaneous, often burying animals, and are believed to be strong enough to break telephone cables on the sea floor. Beds deposited from these currents can be expected to decrease regularly in thickness as the strength of the current progressively dissipates. This can happen in a matter of hours; the sand becomes thinner and finer in the downcurrent direction and finally disappears altogether. Agreement is not widespread, but many geologists believe that turbidity currents are caused by slides that start along the landward margins of a marine basin.

Short, lenticular beds, on the other hand, generally represent erosion and deposition by strong, variable currents in shallow water, such as in modern



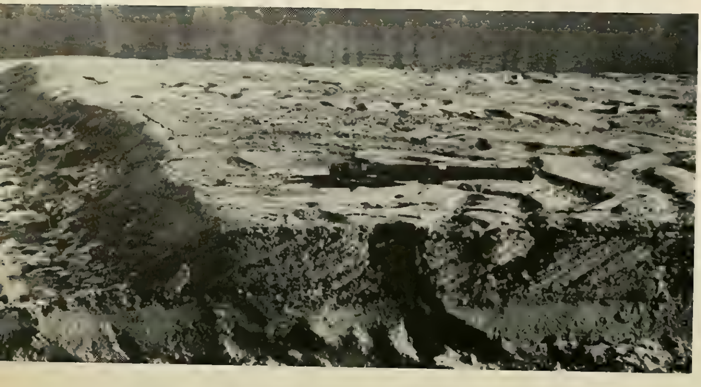
**THICK, massive bedding characterizes this Triassic sandstone formation in Utah, indicating that it was deposited under essentially constant conditions.**

rivers, tidal channels, and ancient deltaic complexes. Isolated erosional channels, probably formed in a matter of hours, days, or weeks after the deposition of a bed, are not uncommon in deposits of this kind.

The foregoing descriptions suggest that one could arrange bedding into an idealized sequence based on the idea of order versus disorder. Highest order occurs when all layers have equal thickness, uniform lateral thickness, and a wide extent. In contrast, maximum disorder prevails when each layer has a different thickness and when thickness varies laterally and the beds have limited lateral extent. If order is high, the geologist infers that the sedimentation was regular and uniform; if order is low, he infers that it was irregular and variable.

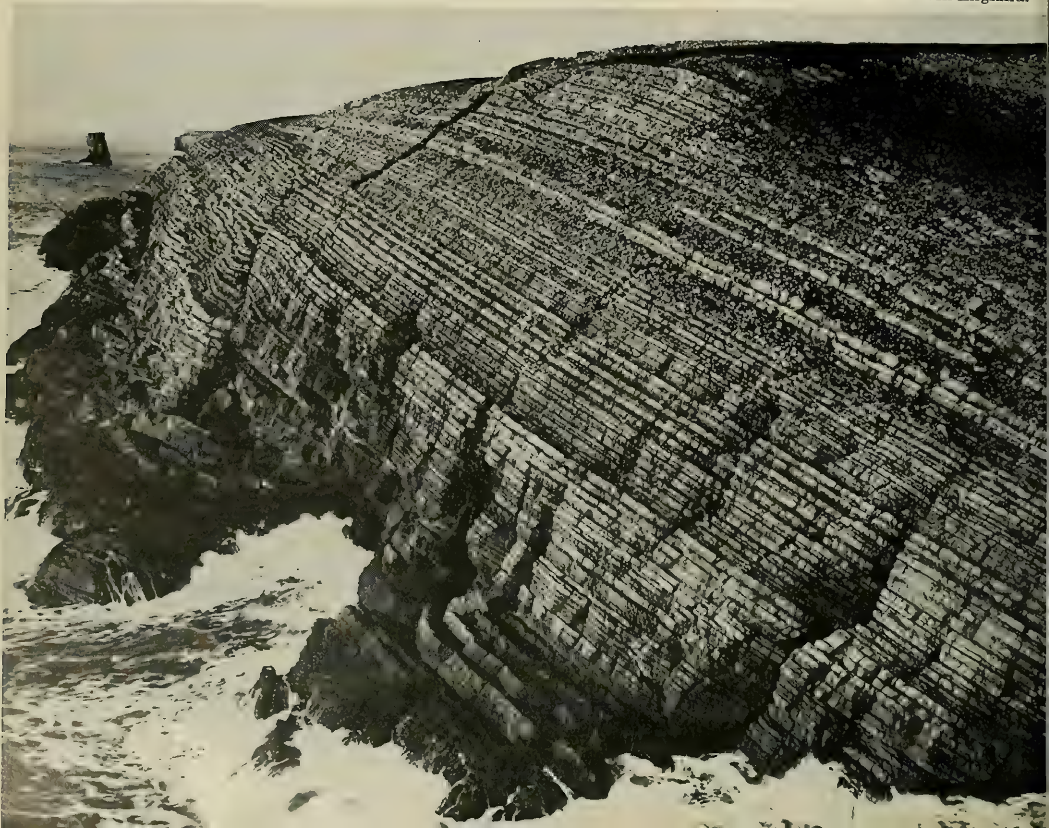
The internal as well as the external organization of a bed contributes significantly to an understanding of its origin. It is easy to miss many sedimentary structures, and when one first looks for them in the field, he may think that most beds are massive—that is, seemingly solid and without internal structure (*photograph, page 51*). Actually, just the opposite is true. But a sharp eye and practice are essential, and at times even the professional must etch surfaces in acid or X-ray thin slices of the sediment to see its internal structure. Different minerals absorb X-rays differently, and the X-ray technique shows structures not visible to the naked eye.

Small-scale current fluctuations produce internal laminations in a bed; these may be parallel or inclined to the bedding planes. The inclined lamination, called cross-lamination, or more simply, cross-bedding, has received much study in recent years



**Cross-bedded** sand layers, at left, were formed during river's last flood stage.

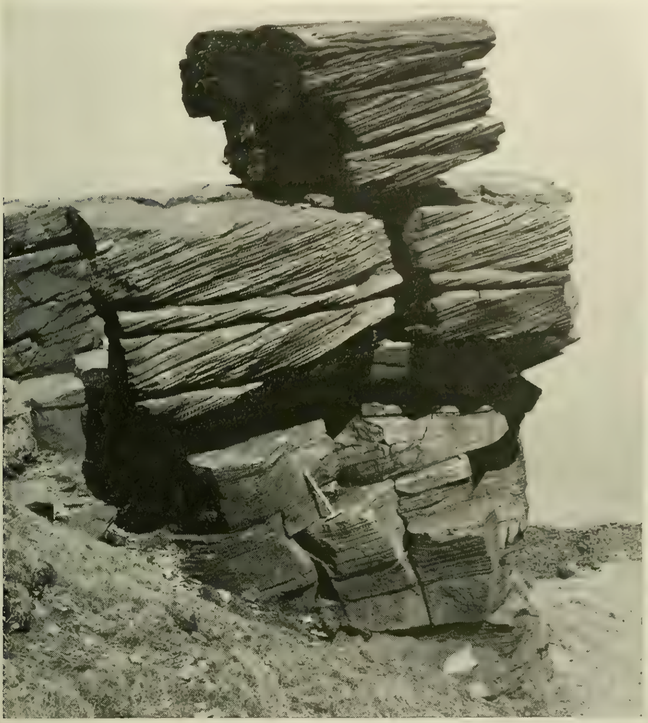
**Lateral continuity** marks this shale and limestone stratification in England.



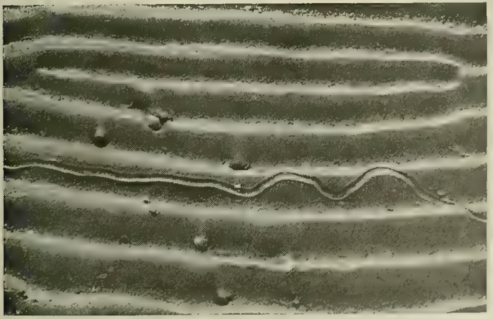
(*see photograph directly below*). Most cross-bedding is formed by sand waves—such as ripples on the beach or dunes in the desert—that result wherever silts and sands are transported by water or air currents. Hydrodynamically, sand waves are caused by the frictional resistance exerted by a granular bed on the moving current, and they can range in height from a few inches to more than one hundred feet. One example is the small sand wave of the Vermilion River in western Indiana, left exposed after the last period of high water, or flood stage, which usually occurs several times a year (*photograph, far left*). Loose sand moved from the right to the ridge's back slope and was carried over its crest to form inclined laminations within the deposit. The current in the river behind the sand wave goes in the direction of inclination of the cross-lamination.

As time passes, a whole series of these units may be deposited, and one can see the cross-bedded internal structure in many ancient rocks. Measuring the direction of the inclination permits one to determine the direction of the ancient wind or water current (paleocurrent) that deposited the sands. This knowledge is useful in reconstructing the direction of ancient river systems and paleowinds, and in finding the sand dispersal pattern in ancient shallow-sea deposits. It has also been used to predict the direction of ancient river channels in the search for uranium deposits, and to predict the orientation of elongate sand bodies that are now reservoirs for oil and gas. In most outcrops the cross-bedded unit varies from one to three feet in thickness. Extremely thick beds—such as those of Navaho sandstone in Utah, which are twenty-five to sixty feet—are exceptional.

GRADED bedding is another internal structure type. This refers to the upward decrease in grain size found in some beds—the larger particles are on the bottom and the smaller on the top—which reflects the waning velocity of a turbidity current. Although graded bedding is a common structure in turbidity current deposits, it is sometimes difficult to see. Geologists can use graded bedding to help determine the order of deposition in sediments that have been folded and deformed by earth movements after



**LAYERS** of cross-bedded sandstone, ***left***, were deposited millions of years ago.



**REGULAR** pulsations of a current of water caused uniform ripple marks on a deposit's top layer. Note the animal trail.

**ASYMMETRICAL** ripple marks in sand were formed by varying patterns of turbulent flow. Current was from left to right.

deposition. Also, most cobbles and pebbles carried along in a stream will incline in the direction of the current. This is an orientation that can be seen easily in ancient gravels and conglomerates.

PROBABLY the first sedimentary structures ever to be described in antiquity were small-scale sand waves called ripple marks. They are almost ubiquitous, and occur in many shapes and sizes (*photographs, page 53*). Although geologists and workers in hydraulics have written much about their origin, much still remains to be learned. Fortunately, recent experiments in large, man-made flumes (long, flat-bottom troughs), where the conditions of flow, size, and sorting of the sand and slope of the bed can be carefully controlled, have contributed much useful information. One theory based on these experiments states that the rippled surface is the equilibrium boundary between two currents of varying density (such as water and water-saturated sand) that are moving at different speeds.

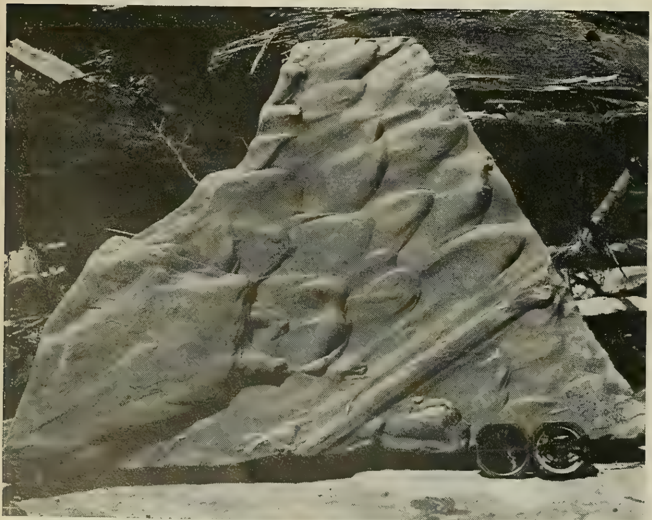
Sole marks on the bottom of a bed —usually found on limestone or sandstone beds interstratified with shale —are among the most fascinating internal markings of all. These were originally called "hieroglyphs," because geologists did not understand their mode of formation. They have also been called "casts," because they are the fillings of depressions formed on the surface of the underlying mud. Hieroglyphs is undoubtedly a good name, for although sole marks were described in upper New York State more than 120 years ago, they have only begun to be better understood in the past fifteen years.

One type of sole mark is formed by currents that either erode the bottom or drag debris—wood, chips of shale, or fossils—over it, producing straight, linear grooves. Strong currents usually produce wide and long grooves, but complicated patterns of turbulent flow will produce asymmetrical scours, or flutes. Sole marks of this type—called "flute casts"—are common in turbidite sequences, and by systematically mapping them in the field, geologists have been able to determine the slope of some ancient marine sedimentary basins. They occur only on the bottom of the bed, and are therefore also a useful guide for the geologist who wishes to determine the order of deposition in areas of complex folding.

Another type of sole mark is *Lebenspuren*—the record of tracks, trails, and burrows left by animals on the bottom of the sea. Careful study of *Lebenspuren* has helped geologists obtain a better picture of the details of deposition, such as relative sedimentation rate, water depth, and degree of oxygenation of the water at the sea floor. The unequal loading of sand over a muddy bottom also produces bottom structures, as the overlying sand protrudes down into the mud.

Other types of bedding are disturbed and deformed. Gravity structures, for example, are formed before consolidation, when sediments are affected by foundering or by downslope sliding. These movements may produce only a slight modification of the layering, but they can lead to pronounced folding and even liquefaction. Such foundering is closely related to the conditions that produce quicksand — a water-saturated sand that will crumple stratification and flow under its own weight. Mud-eating organisms, too, can disturb the lamination, causing "churned" deposits. Beds are also deformed by escaping fluids and gases.

THE study of primary sedimentary structures is probably most important because it gives us information about the environment of deposition of an ancient rock. Was the sand deposited by ancient streams on beaches or in a deep ocean? If a sandstone is characterized by abundant cross-bedding, the sand was probably deposited long ago by rivers, by wind, or by currents in a shallow sea, but not in a deep ocean basin and probably not on a beach. To distinguish between the river, wind dune, and shallow-sea environment, however, the geologist would need more information. If marine fossils are present, he can exclude the dune and river environments. But if abundant plant material, small erosional channels, and lenticular beds are found, then deposition by a river is probable. Thus it is a combination of elements that indicates a sediment's origin. Once the environment of deposition has been identified, the interpretation of an ancient current system is vastly simplified. Although only a tiny fraction of a deposit is available for observation, the study of primary sedimentary structures is an important factor in helping the geologist outline, with considerable confidence, the original slope and shape of the sedimentary basin in which the deposit occurs.



FLUTE MARKS and linear grooves are found on undersides of some ancient beds. They are casts of depressions made by erosion in underlying mud.

OUTCROP of cross-bedding in Utah was probably formed by wind currents.

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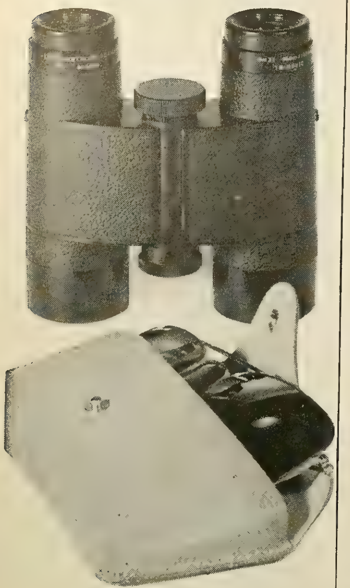

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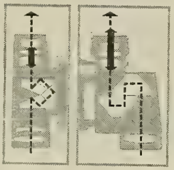

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# About the Authors

Currently Professor of Anthropology at the Illinois Institute of Technology in Chicago, Dr. Edward T. Hall recently completed a three-year study on man's perception and use of space. His article, "Territorial Needs and Limits," is based on material in his forthcoming book, *The Hidden Dimension*, which will be published by Doubleday and Company in 1966. Dr. Hall is a well-known lecturer and writer who has also done research on Micronesian culture. His study on man and space was financed by the National Institute of Mental Health.

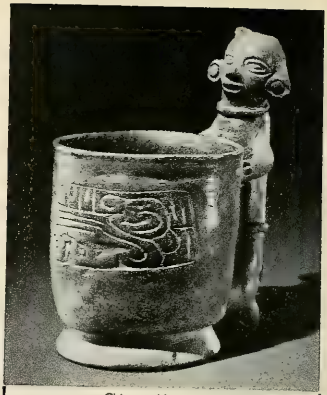
Dr. Harold W. Scheffler, who wrote the article on *kesa* politics, is Assistant Professor of Anthropology at Yale University. He spent from 1958 to 1961 studying social structure on Choiseul Island, and he has also studied the Ojibwa Indians of Manitoba and North Dakota. His book, *Choiseul Island Social Structure*, was published in 1965 by the University of California Press.

" 'Sleeping One' of the Hopis" is taken from a chapter in Edwin Way Teale's latest book, *Wandering Through Winter*, published in 1965 by Dodd, Mead, and Company. Mr. Teale is a distinguished writer, naturalist, and photographer, whose work has often appeared in Natural History.

Shirley Alexander, author of "Base and Noble Metals in Illumination," is a faculty member and Research Assistant in Ancient Metals at the Conservation Center of New York University's Institute of Fine Arts. Miss Alexander has her M.A. in medieval art and a Diploma in Conservation of Art Objects from the Institute, and holds two B.A. degrees (in modern languages and art history), a Slade Diploma in Fine Art, and an Art Teachers' Diploma from the University of London. She has been a conservator for several archeological excavations.

An author of many books and articles on plants and lawns, and a leading authority on the seeding and maintenance of turf, Dr. Robert W. Schery, who wrote the article on Kentucky bluegrass, is Director of The Lawn Institute in Marysville, Ohio. His major research interests include tropical floristics and economic botany.

Dr. Paul Edwin Potter, author of "Sedimentary Origins of Rock Layering," is Associate Professor of Geology at Indiana University. His research interests include primary sedimentary structures, sedimentary petrology and sedimentation, and primary directional properties of sedimentary rocks. He has co-authored two books with Dr. F. J. Pettijohn—*Paleocurrents and Basin Analysis* and *Atlas and Glossary of Primary Sedimentary Structures*, published by Springer-Verlag—from which photographs for the article were taken.



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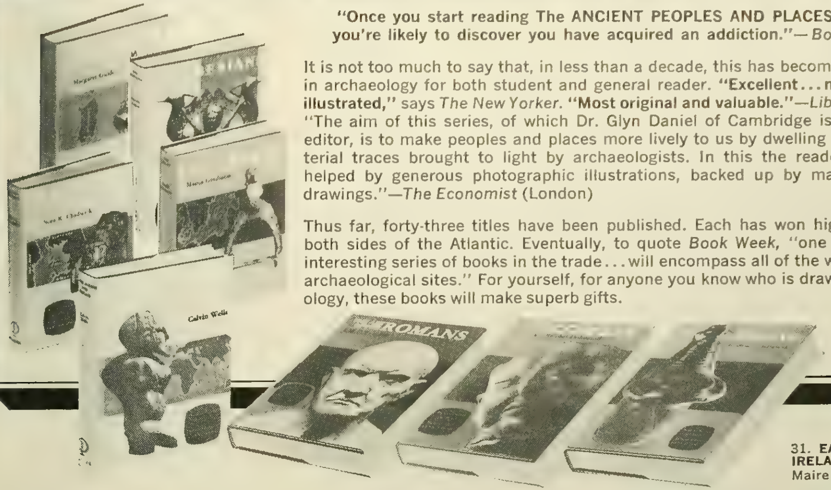

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# nature and photography

## movie problems in public aquariums

### by Sam Dunton

NOT too many years ago, only an accomplished photographer would attempt to make motion pictures in a public aquarium. Today, however, faster lenses and films, improved cameras, and advanced techniques in aquarium exhibition enable the photographic amateur to make perfectly acceptable footage of the exotic fishes and many other strange and beautiful inhabitants of the average public aquarium or oceanarium. While such pictorial records may be good, they also may be inferior if judged by accepted standards. The awareness of a few simple photographic facts makes the difference.

The great common denominator for successful aquarium filming is the light meter—don't mistrust its readings! Most exhibition halls in public aquariums are dimly lit and, although the tanks of colorful fishes appear brilliantly illuminated by comparison, in many instances the dominant lighting is considerably less than normal sunlight. The meter reveals this fact, but it is often difficult for the camera operator to accept it. The fishes "look so bright!"

A low level of existing light presents no problem for the professional cinematographer: he simply employs enough artificial light of appropriate color temperature to match the sensitivity of the particular emulsion he is using. For the conscientious amateur, limited to existing light, it can be a problem. The solution obviously is to use fast film and fast lenses, and to limit one's photography to those tanks that are adequately illuminated by natural or by artificial means. Also, many fishes remain virtually motionless for varying periods of time or swim slowly, enabling the photographer to reduce his camera speed—say from 16 frames per second to 8—and thus double his exposure when encountering poor light conditions. The action will be accelerated when the film is projected at the normal speed of 16

*This stunning composition is worthy of John James Audubon. Arrow points to the nervous but unafraid Water Turkey, hundreds of feet from a standard Questar. Above is image Questar reached out and delivered to 35-mm. negative ready for enlargement. Tri-X, 1/250 second.*

We included the sprocket holes of this 35-mm. negative for clarity. Beautiful 11x14 enlargements are practically grainless. Questar telescopes are priced from $795. They make possible sharp wildlife photographs like this without tents or towers or stalking blinds. At left the versatile Standard Wide-Angle Model. The latest Questar booklet now has 40 pages, 8 of them in color, and has a long essay on what we have learned about telescopic photography in 10 years. One dollar postpaid in U.S., Mexico and Canada. By air to West Indies and Central America, $2.30. By air to Europe, N. Africa and S. America, $2.50. By air to Australia and elsewhere, $3.50.

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frames per second, but the results can be quite satisfactory, particularly if the camera has been firmly supported by a tripod and the speed of any panning action reduced by half.

At the outset, the amateur cinematographer has considerably faster color films at his disposal than did his counterpart a decade ago. Color emulsions at that time boasted an ASA speed of 10 daylight, while today, 8 mm. films have been increased to 25, and 16 mm. films have speeds to 160 and 200!

In 1953, while producing a classroom film on reptiles, I had occasion to make a sequence of the swimming movements of giant sea turtles. This was made in one of the large tanks at Marine Studios, Marineland, in Florida, and at depths up to 10 feet I was able to get normally exposed footage on Kodachrome I (ASA-10) at f/2 and a camera speed of 24 frames per second. The pictures were made through a glass port in the side of the tank, and illumination was hazy sunlight. By contrast, two summers ago at the New York Aquarium at Coney Island, I made a sequence of a diver feeding belugas, or white whales, in the big oceanic tank that is equipped with underwater viewing windows. With bright sunlight and clear water, my exposure on Kodachrome II (ASA-25) was f/4 at 24 frames per second, and f/5.6 in the brighter areas of the tank!

### Movie Lights Banned

The casual photographer in a public aquarium is apt to look with envy at a professional cameraman filming a tank brilliantly illuminated with movie floods and spots. Actually, the amateur is not at as great a disadvantage as he may think. The professional uses lights because he must accomplish his shooting in a minimum time, and must produce an original film that will lend itself to suitable internegatives needed to produce completed release prints in quantity. Even then, he can only work with fishes that will tolerate the higher light level—many will not. In such instances, the professional must rely on faster emulsions and greatly reduced lighting. He must also use extreme care in the placement of his lighting units to produce a lighting that will reveal the fishes in a normal aspect. The motion picture amateur does not have this problem with existing light, for the staff of an aquarium or oceanarium usually provides the best type of lighting for viewing the exhibits. This can readily be utilized for good filming.

Recently, I have received a number of inquiries about the use of battery-operated movie lights of the "sun-gun" type for photographing fishes. I am sure the use of such equipment in a public aquarium would encounter opposition from the staff. For instance, Paul Montreuil, Director of the New York Aquarium, while not opposed to the use of conventional flash lamps or electronic flash for still pictures, definitely feels that the steady brilliance of portable movie lights would be detrimental to many fishes. His opinion is undoubtedly shared by others charged with the maintenance of public aquariums. In any event, permission should be gained and prior arrangements made if the serious amateur wishes to use auxiliary lighting equipment of any kind.

### Speed, Focus, and Color

A 16 mm. camera will generally provide the optimum combination of fast lenses, variable speeds, and through-the-lens focusing and viewing so essential for good results in aquarium filming. The availability of through-the-lens focusing is particularly important, because in most tank photography the field of sharp definition is narrow, especially when lenses of long focal length are employed. In addition, the refractive power of water causes a foreshortening of the distance from camera to subject, altering the linear scale, but if the subject is sharp on the ground glass, it will be sharp on the film.

Variable running speeds are important for slowing the camera to gain exposure on dimly lit subjects, or for speeding it up for slow-motion effects of the action of large marine mammals, such as sea lions or porpoises, leaping above the surface of their pools. A sturdy tripod with a smoothly operating tilt and panhead is essential for steady, sharply defined pictures, especially when telephoto lenses are employed. A zoom lens, when used at other than wide-angle or normal settings, is basically a telephoto lens, and the camera should always be firmly supported when the zoom effect is operated.

It is not easy to give a concrete answer to the query, "What is the best color film to use for aquarium photography, Daylight or Type A?" These are Eastman Kodak's designations for films corrected for use under daylight conditions, or for artificial (photoflood) illumination. No particular problems will be encountered with a daylight emulsion in tanks illuminated by sunlight, direct or diffused. The use of a "skylight," or ultraviolet correction, filter will give a warmer result in tanks illuminated by daylight—without direct sun, and particularly when blue skies predominate. A daylight emulsion is also best for tanks illuminated by fluorescent lamps, although some greenish light is emitted by these tubes.

In tanks illuminated by Mazda (conventional household) lamps, an artificial light emulsion would more closely approximate the natural coloration of the subject. A color temperature meter and a set of correction filters would resolve the problem with considerable certain-

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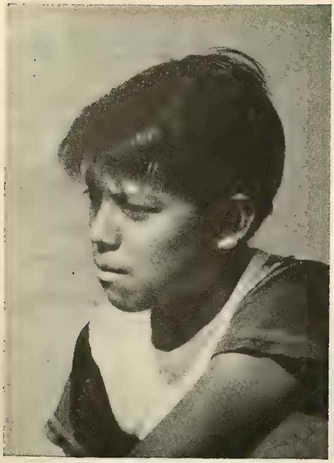

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ty, but might not provide a complete answer, for aquariums sometimes employ mixed types of artificial light for special effects. Actually, in practical filming it is permissible to "gild the lily" to some degree, and it is better, with the majority of underwater subjects, to err on the warm side than to present colder tones. For this reason, if I were limited to one emulsion, I would choose a fast color film corrected for artificial light, together with the necessary filters to correct it for colder lighting. While extremely fast color emulsions show a definite grain pattern on the screen, this is not particularly noticeable, as most underwater subjects appear against backgrounds of varied patterns.

### A Choice of Approach

Now that we have examined the mechanics of aquarium filming, let's look at the aesthetics. There are, of course, many ways to photograph fishes in public aquariums; however, it has been my experience that they can be resolved into two operational approaches.

First, one may choose to record underwater scenes for their aesthetic appeal alone, without too much regard for the particular characteristics of the animal being photographed. This approach relies—or should rely—almost entirely on the application of natural light or tank light. The camera simply records what the eye observes.

Secondly, if the photographer is willing to spend some time studying the habits of various fishes, he has the opportunity of presenting the specimens in some significant phase of their normal routine—feeding, nest building, or exhibiting aggressive and defensive behavior employed in defending their small preserves against the intrusion of undesirable poachers.

To attain footage of value, the operator who uses either method, or a combination of both, should always be prepared to render accurately the elements of composition, beauty, and graphic presentation engendered by the normal postures of underwater inhabitants.

In a great many instances, a photographer's failure to achieve his objectives can be the result of underexposed film; he has taken his meter reading from the brighter areas of the tank rather than from a more neutral portion, such as rockwork, which has both high lights and shadow areas. Color emulsions currently in use possess considerably more latitude than did those of an earlier era, and if high-light and shadow readings are averaged, a high proportion of the footage will be correctly exposed.

Care also must be exercised to operate one's camera only when the fishes are in optimum position in reference to the dominant lighting, and every effort must be made to avoid the reflection of light colored walls, exhibition-hall lights, o illuminated tanks behind the photographer. Added hazards to definitive, clea footage are reflections of bright meta railings close to a tank or ornamenta tank frames in the area into which you are photographing. Avoid, too, reflections of the camera. This can usually be accomplished by photographing from one side, rather than directly into the glass tank front. When a head-on camera position is unavoidable, it sometimes may be necessary to drape camera and tripod with black cloth; in such instances, your own clothing should be as dark as possible.

Always keep your lens as close to the tank as working distance permits. The smaller the area of glass expanse you have to deal with, the less chance there is of including scratches, bubbles, and finger marks. A small area can readily be cleared of finger smears by a well-directed breath and immediate polishing with a soft handkerchief. A pocket flashlight is useful for detecting such smears, as well as for speedy adjustment of camera settings in the semi-darkness of an exhibition hall.

No matter what camera you use, almost any public aquarium or oceanarium will provide an immense amount of interesting and exciting subject matter for casual filming or more extended shooting sessions. Even the simplest motion-picture camera is capable of recording some aquatic subjects; more elaborate equipment will extend your scope and increase your percentage of good film. The New York Aquarium, operated by the New York Zoological Society, puts on an exciting show with its white whales and Antarctic seals, and tank after tank of exotic fishes provide a multitude of opportunities for the amateur photographer.

Many aquariums and oceanariums give special assistance to photographers; some provide exquisitely arranged tanks with push-button photo illumination, together with labels showing the proper exposure factors for various films. Some of the institutions that exhibit trained troupes of aquatic mammals will cue you via a public-address system as to the exact instant to start your camera rolling to catch a given act at the height of its display.

Both in the United States and abroad, new and exciting displays of strange and beautiful forms beckon the beginner as well as the advanced amateur cinematographer to share visually—and to capture on film—the myriad dwellers of the "world of water!"

---

**Mr. Dunton, who is a director of the Biological Photographic Association, Inc., serves as the Staff Photographer of the New York Zoological Society.**

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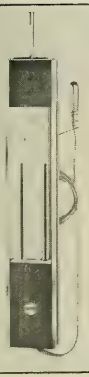

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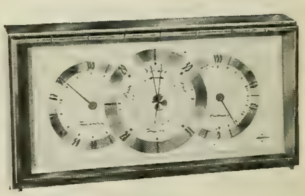

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SCIENCE IN ACTION

# Survey of the Bahamas

By C. Lavett Smith

On June 15, 1964, the research vessel *J. A. Oliver* left Bimini for a month of exploratory work in the southern Bahama Islands. Her departure marked the beginning of the actual field work for an extensive biological survey of the Bahamas, a projected four-year study sponsored by the United States Office of Naval Research and conducted by the Lerner Marine Laboratory with the cooperation of the Bahamian government. During this time dozens of scientists interested in the natural history of the Bahamas will participate, each pursuing studies in his own field of interest and competence. The result will be a body of information about the Bahamas that will be available for the use of other research workers. Studies on the distribution and abundance of Bahamian plants and animals, the types of habitats and the extent of each, and life histories and interrelationships of organisms will be emphasized, but any study that can contribute to the interpretation or understanding of this information will be encouraged.

The Lerner Marine Laboratory is a field installation of The American Museum of Natural History, and is located on North Bimini in the northwestern Bahamas. Established in 1948 and named for the original donor, Michael Lerner, the laboratory has flourished and grown for the past seventeen years. Research workers from all over the world have utilized the facilities for a broad array of investigations, ranging from molecular biology to animal behavior, from geology to biochemistry. Plants, protozoans, corals, sea cucumbers, fishes, and porpoises have been studied, and in 1961 the world's most complete facilities for research on large sharks were installed under the guidance of Dr. Perry Gilbert, Professor of Zoology at Cornell University and a Research Associate of the Lerner Marine Laboratory.

## Research Facilities Offered

The Laboratory is devoted to basic research, and it has always been its policy not to accept commercial or industrial research projects. For the first few years, qualified workers were invited to use the facilities of the Laboratory without charge as guests of The American Museum. Today, however, there is a modest fee for the use of laboratories and residence rooms; reservations must be made several months in advance to insure maximum use of space and equipment.

The Laboratory area is a self-contained unit with living quarters on the grounds for the scientists. The kitchen is staffed with excellent cooks; the rooms are clean and comfortable. There is an electric power plant, a machine shop, a carpentry shop, a laundry, a dock for the fleet of small craft, chemical and equipment storage areas, and well-equipped laboratories with a coldroom, a dryroom, a photographic darkroom, an aquarium shed, and several large outdoor tanks. There are also several fenced-in areas for larger animals.

The total Laboratory grounds extend across narrow North Bimini. To the east is the Bimini lagoon, a shallow, semi-enclosed area dissected by a deep channel. Mangroves line the eastern shores of the lagoon, which is world famous for its excellent bonefishing. West of the Laboratory the bottom drops off to the depths of the Straits of Florida. The Gulf Stream flows through these straits, and its edge lies less than a half mile from the Laboratory grounds. This proximity of the Gulf Stream, with its marlins, sailfishes, and broadbills, has made Bimini one of the most famous big-game fishing areas in the world.

There are many advantages to the Bimini location that attract biological workers. First is the subtropical climate, which permits field work all year round with only occasional, short interruptions during the hurricane season. Then there is the variety of tropical marine organisms available for study. (Because of the pattern of ocean currents in the Northern Hemisphere, the marine organisms are tropical West Indian in affinity.) The Bahamas are truly oceanic islands separated from continental North America by nearly sixty miles, and its waters are exceptionally clear, permitting many kinds of direct observation. Although this oceanic origin means an impoverished terrestrial flora and fauna, the lack is more than offset by the profusion of marine organisms.

Geologists find in the Bahamas an almost unrivaled opportunity to study shallow marine seas closely resembling the epicontinental environments of the geologic past. Here, perhaps better than anywhere else in the world, the paleontologist and geochemist can study the conditions under which past faunas flourished and were preserved. All these studies are enhanced by the availability of a well-equipped laboratory twenty minutes by air from Greater Miami.

During the time the Laboratory has been in existence, over 250 papers have been based on work done there, either partly or wholly. It is unlikely that investigators will ever run out of subjects o investigate at Bimini, but it is obvious that the scope of materials available will be increased if the studies are extended to other parts of the Bahamas. The Bahama Survey is the first step in expanding the Laboratory's activities beyond Bimini itself. It is hoped that eventually a series of field stations can be established throughout the Bahamas where investigators can work for extended periods away from the Bimini headquarters. But before these field stations are developed, we must know more about the remoter areas, so the survey is being conducted to acquire a general background of familiarity.

## Organization at Sea

THE *J. A. Oliver*, a rugged, 65-foot, steel-hulled, diesel-powered T-boat, has been specially modified for biological surveys. There is a laboratory below deck, sleeping quarters for six scientists and two crew members, a running seawater system, and ample work space on the deck. Powerful winches can handle nets and other types of gear. Microscopes, centrifuges, nets, dredges, bottom samplers, and an air compressor for filling Scuba tanks are among the equipment normally aboard, and special equipment can be installed as it is needed by the participating scientists. Two outboard-powered skiffs are carried for use in shallow waters.

The crew consists of a captain and an engineer, and scientists are asked to lend a hand when the vessel is docking and at other times as they are needed. The scientists also share the cooking and kitchen chores and stand wheel watches when the vessel is under way, and no one has yet complained that such tasks interfere with research work. Scientists usually find that helping with a line or steering the vessel during a night run is extremely satisfying.

The first step in the survey was a five-day reconnaissance flight over most of the Bahamas in a chartered amphibious aircraft. This flight served to familiarize key personnel with the general features of Bahamian geography. Next, the survey was advertised in scientific journals, and scientists with an interest in the Bahamas were invited to submit projects to a co-ordinating committee. This committee selects those appropriate to the survey and organizes the cruises. Considerable thought goes into the planning of these cruises so that everyone on board can make efficient use of his field time. It would, for example, be unfortunate if all the projects on one cruise required the use of the main vessel so that each scientist had to wait his turn with nothing to do in between. If possible, we try to have one or two scientists working with terrestrial organisms on each cruise.

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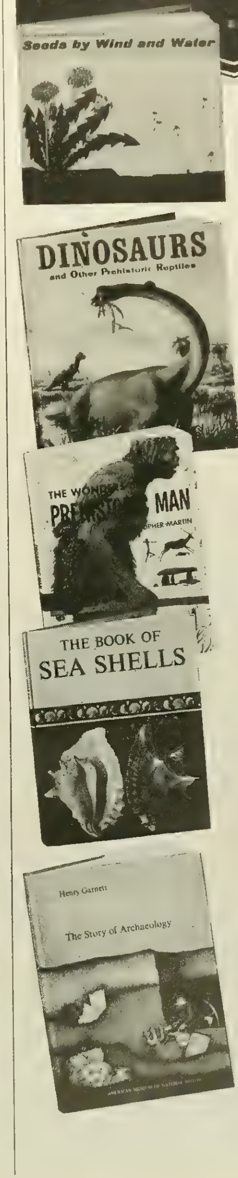

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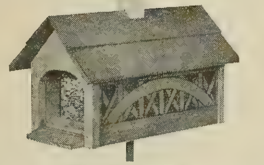

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In scheduling these runs, many factors must be taken into consideration—the equipment needs of the project, the conditions at that particular time of year, the area where the study is to be conducted, and alternatives in case there is difficulty in securing materials.

## Project Selection

Selection of the projects is the only control that the Museum exercises over the survey; once a project is accepted, all responsibility rests with the investigator who is then free to conduct the research and publish the results as he sees fit. Here the Museum is acting as a service organization whose function is to make the research possible without dictating in any way how it is to be done.

The first cruise of the survey extended from June 15 to July 15, 1964. A Princeton geologist and his wife were dropped off at Andros Island, where they remained for the summer studying the role of blue-green algae in carbonate deposition. The rest of the party then continued on to Great and Little Inagua in the southern Bahamas. Several brief stops were made at intermediate points. This allowed the scientists to collect comparative samples and gave us a chance to select areas where intensive studies will be conducted later.

The second cruise to San Salvador (or Watlings Island, as it is often called) was conducted during November, 1964. This time, intermediate stops were made at Eleuthera, Little San Salvador, and Cat Island. Future cruises will be scheduled to include all parts of the Bahamas and the related Turks and Caicos Islands.

The Bahama Islands are located on a huge series of shallow banks that rise from depths of 500 to 2,000 fathoms to within less than 30 feet of the surface of the sea. The total area of these shallow banks is estimated to be over 60,000 square miles. During geological history, lowering of the sea level exposed the banks, and winds piled calcareous sands along their edges. These ancient dunes, now lithified, form most of the land masses, with some additional marine limestone formed when the sea level was slightly higher than it is at present.

Altogether there are an estimated 3,000 islands in the Bahamas, ranging in size from small rocks to giant Andros Island, which is roughly the size and shape of Puerto Rico—100 miles long and 40 miles wide. Because of this areal spread, there is a considerable diversity in climate. Perhaps the most obvious feature is the aridity in the southeastern islands, many of which are uninhabited because of the lack of fresh water. Only Andros Island has flowing streams.

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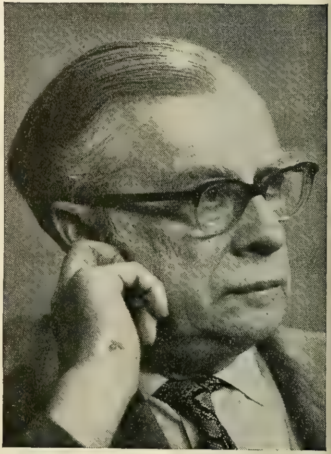

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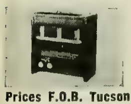

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DR. SMITH is Assistant Curator in the Department of Ichthyology of The American Museum, and Codirector of the newly organized Bahama Survey.

Most of the land is only a few feet above sea level. The maximum elevation (on Cat Island) is slightly over 200 feet. Usually the center of each island is lowest, and some of these natural basins are used for evaporating sea water for salt—especially in the dry southern islands. The hills are usually in rows along the windward coasts. The land is extremely rocky, and there is a general lack of soil, which has restricted agriculture—drastically so in the southeast. Some of the larger northern islands support pine forests, and lumbering is an important industry, but the dry southern islands have only low desert-type shrubs.

The arrangement of the Bahamas on a series of shallow banks constitutes what is, in effect, a series of natural biogeographical experiments. Banks are of varying sizes, from tiny, atoll-like Hogsty Reef, slightly over five miles in its greatest dimension, to the Great Bahama Bank, with a north-south dimension of over three hundred miles. They are also at varying distances from each other. Since many marine organisms travel from one area to another as larvae swept by ocean currents, the Bahamas offer opportunities to test the effectiveness of this type of passive transport through comparative studies of thorough collections from many localities.

That a natural history museum in New York City should be involved in a study of the Bahama Islands may seem strange until one realizes that the Museum, through its research activities, is as concerned with the acquisition of new knowledge as it is with the dissemination of known facts through its exhibits, publications, and educational programs. The Bahama Survey is one program designed to aid Museum staff members and other scientists in their studies of the natural history of marine organisms. It is a small part of the Lerner Marine Laboratory's activities, which is in turn only one facet of the vast research facilities of The American Museum of Natural History.

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This list details the photographer, artist, or other source of illustrations, by page.

COVER—Lee Boltin
12—Karl W. Kenyon
13—Karl H. Maslowski, Photo Researchers, Inc.
14-15—top, Ted Keil, New York Herald Tribune; bottom, Emil Schulthess, Black Star
16-18—AMNH after Edward T. Hall
19—Hubert C. Birnbaum
20-25—Harold W. Scheffler
26-29—Edwin Way Teale except 27—center, Kenneth Middleham
30-39—Lee Boltin except 35—top, Blakeslee, Inc., Courtesy of Walters Art Gallery, Baltimore
40—AMNH Archives
42—top, Ohio Historical Society; bottom, The Lawn Institute
43-44—AMNH after Robert W. Schery
45—The Lawn Institute
46-47—Mount Wilson and Palomar Observatories
49—AMNH
50—Paul Edwin Potter
51—W. K. Hamblin
52—top, Paul Edwin Potter; bottom, Geological Survey of Great Britain
53—top, J. S. Shackleton; bottom left, Senckenberg am Meer; bottom right, Paul Edwin Potter
54—N. L. McIver
55—W. K. Hamblin

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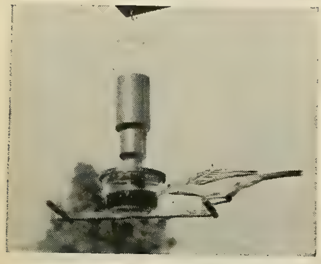

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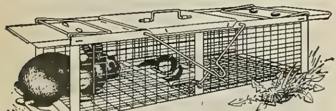

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# Suggested Additional Reading

## TERRITORIAL NEEDS AND LIMITS

Social and Endocrine Factors Are Integrated in the Regulation of Growth of Mammalian Populations. John J. Christian and D. E. Davis. *Science*, December 18, 1964, pages 1550-60.

Of Men and Marshes. Paul L. Errington. The Macmillan Co., N.Y., 1957.

The Evolution of Territorial Behavior. H. Hediger in Social Life of Early Man, edited by S. L. Washburn. Viking Fund Publications in Anthropology, No. 31, N.Y., 1961.

The Stress of Life. Hans Selye. McGraw-Hill Book Co., N.Y., 1956.

## BIG MEN AND DISKS OF SHELL

Argonauts of the Western Pacific. Bronislaw Malinowski. George Routledge & Sons, Ltd., London, 1922.

The Politics of the Kula Ring. J. P. Singh Uberoi. Humanities Press, N.Y., 1962.

Anthropology and the Study of Politics. M. Fried in Horizons of Anthropology, edited by Sol Tax. Aldine Publishing Co., Chicago, 1964.

## BASE AND NOBLE METALS IN ILLUMINATION

The Materials and Techniques of Medieval Painting. D. V. Thompson. Dover Publications, N.Y., 1957.

On Divers Art. Theophilus. Translated by J. G. Hawthorne and C. S. Smith. University of Chicago Press, 1963.

Early Medieval Painting. A. Grabar and C. Nordenfalk. Skira, Olten, 1957.

Gothic Painting. J. Dupont and Cesare Gnudi. Skira, Geneva, 1954.

## THE MIGRATION OF A PLANT

The Lawn Book. Robert W. Schery. The Macmillan Co., N.Y., 1961.

Grasses and Grasslands. Colin Barnard, Editor. St. Martin's Press, N.Y., 1964.

Bluegrass' Grassroots Empire. Robert W. Schery. *Economic Botany*, January-March, 1959.

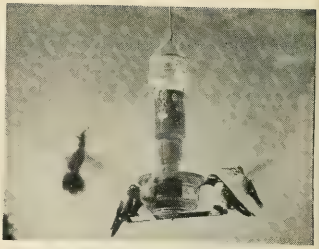
## SEDIMENTARY ORIGINS OF ROCK LAYERING

Stratigraphy and Life History. Marshall Kay and Edwin H. Colbert. John Wiley & Sons, N.Y., 1965.

Stratigraphy and Sedimentation. W. C. Krumbein and L. L. Sloss. W. H. Freeman & Co., San Francisco, 1951.

Basic Concepts of Physical Geology. Edgar W. Spencer. Thomas Y. Crowell Co., N.Y., 1962.

Approaches to Paleoecology. John Imbrie and Norman Newell, Editors. See chapters by E. D. McKee and Adolf Seilacher. John Wiley & Sons, N.Y., 1964.



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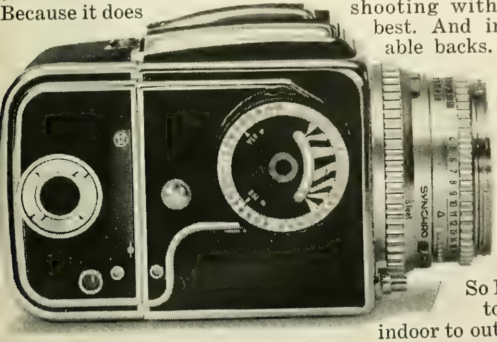
# Is Jerry Schatzberg part of "the system"? Or vice versa?

*Clockwise: Hasselblad 500C with 80mm lens and light meter knob, 150mm lens, sunshade, filter, eye-level prism finder, 250mm lens, magnifying hood and film magazine.*

We don't really know. But let us explain. "The system" we refer to is the Hasselblad system. And it offers the photographer a unique and complete combination of interchangeable components that allows for greater versatility than anything called "camera." Because it does more, photographers depend on it more. To the exclusion of "cameras." And after a while we wonder whether they become part of it, or it of them? We asked Jerry Schatzberg.



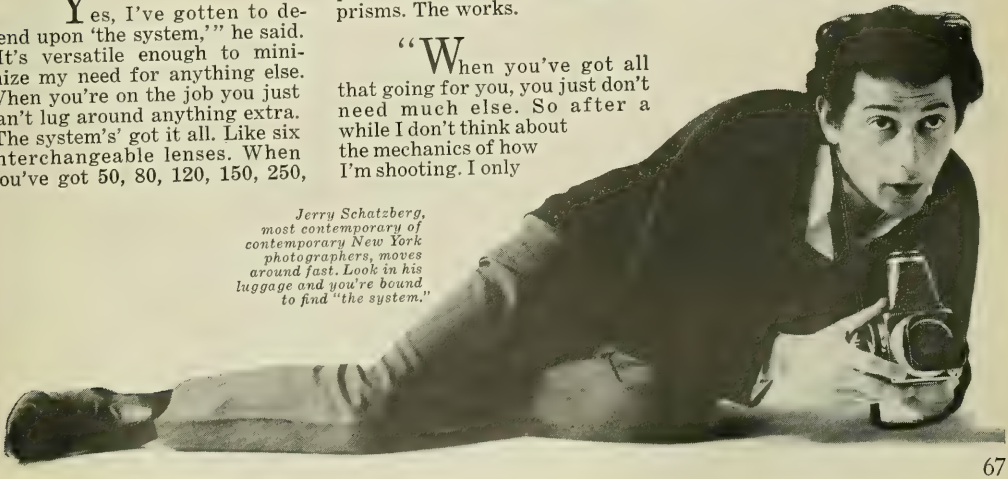
"Yes, I've gotten to depend upon 'the system,'" he said. "It's versatile enough to minimize my need for anything else. When you're on the job you just can't lug around anything extra. 'The system's' got it all. Like six interchangeable lenses. When you've got 50, 80, 120, 150, 250, and 500mm lenses, there's nothing you can't take. And when they're all Zeiss, with manual and automatic diaphragm, and coupled EVS system, you know you're shooting with the best. And interchangeable backs. If I didn't have 'the system,' I'd have, say, three or four cameras loaded with different film. Not for me. 'The system' has 4 interchangeable magazines, 3 for roll film, one for cut film. So I can go from color to black and white, indoor to outdoor film, mid-roll.

"Viewfinders, too. 'The system' lets me see the shot the way I want to see it. (Not any one set way like with 'cameras.') It gives me a choice of eye-level prisms, magnifying hoods, reflex prisms. The works.

"When you've got all that going for you, you just don't need much else. So after a while I don't think about the mechanics of how I'm shooting. I only think about shooting. You might say 'the system' becomes an extension of myself."

There's our answer: "The system" *does* become part of Jerry Schatzberg. It never gets in the way of the picture. It leaves the photographer free to see, to feel, to shoot. Take 5 cameras out with you. See how much or how little they get in your way. You'll let "the system" become part of you. For literature write: Paillard Incorporated, 1900 Lower Road, Linden, New Jersey.

**HASSELBLAD**



*Jerry Schatzberg, most contemporary of contemporary New York photographers, moves around fast. Look in his luggage and you're bound to find "the system."*

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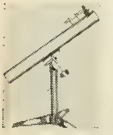

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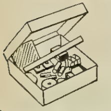

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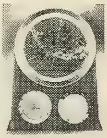

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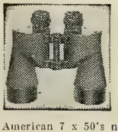

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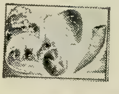
### AGES-OLD FOSSIL COLLECTIONS



Millions of years old! 3 full sets—30 fantastic plant and animal fossils—all for $3.75. EARTH SCIENTIST SET: Dinosaur bone, crinoid stem, horn coral, worm tubes, petrified wood, bryozoa stem, lamp shell, scallop, sea urchin, oyster, clam, snail fossil. CARBONIFEROUS SET: Brachipod, worm burl, crinoid stem, fusuline, horn coral, bryozoan, snail and clam. CRETACEOUS SET: Brachipod, oyster, sea urchin, pertified wood etc. All three sets for one low price!

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### 50-150-300 POWER MICROSCOPE

Amazing Value — 3 Achromatic Objective Lenses on Revolving Turret! Imported! The color-corrected, cemented achromatic lenses in the objectives gives you far superior results to the single lenses found in the microscopes selling in this range. Results are worth the difference! Fine rack and pinion focusing.

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**MOUNTED 500 POWER OBJECTIVE**

Threaded for easy attachment on above microscope. Achromatic lenses for fine viewing. 3 mm. focal length.

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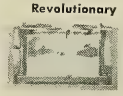
### Revolutionary Technological Breakthrough in
### LIVING UNDER WATER
### Underwater Ant Nest Used to Dramatize Development



Sensational new development may be forerunner to underwater cities, the day man will live under the sea. Silicone Rubber Membrane enables ants (and other creatures) to live and breathe normally **by obtaining life giving oxygen from water** even though ant nest is submerged and sealed off completely from atmosphere. When ants consume oxygen in nest, pressure decreases below that of oxygen pressure in the water—allows oxygen from water (but not water) to pass through membrane. When carbon dioxide pressure increases inside nest it passes out through membrane. 3" x 5" membrane (.001" thickness) is bonded to dacron mat for mechanical strength and made exclusively, by hand craftsmen, for Edmund Scientific's experimental customers. Nest comes complete with sand, food, certificate to be returned for supply of ants. Complete instructions. Supply limited. Use your aquarium or order ours, listed below.

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**2½ GALLON PLASTIC AQUARIUM**
**Stock No. 90,014-E** ........................ ........ ............... **$7.95 Ppd.**

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# for CHRISTMAS GIFTS!

## 'FISH' WITH A WAR SURPLUS GIANT MAGNET

### Bring Up Under-Water Treasures

Real fun! Profitable, too! Simply trail this powerful 5 lb. Magnet out the stern of your boat—retrieve outboard motors, fishing tackle, anchors, other metal valuables. Alnico V-Type Magnet has terrific lifting power—2000 Gauss rating—lifts over 150 lbs. on land—more under water. Many industrial uses, too: recover tools and parts from inaccessible spots, hold work in place, rid shop floors of metal fragments, pins, etc.

Stock No. 70,571-E 5-lb. Magnet $12.50 Pstpd.
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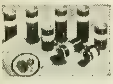

Do a Crystallography project illustrated with large beautiful crystals you grow yourself. Kit includes the book "Crystals and Crystal Growing" and a generous supply of the chemicals you need to grow large display crystals of potassium aluminum sulfate (clear), potassium sulfate (purple), potassium sodium tartrate (clear), nickel sulfate hexahydrate (blue green) or heptahydrate (green), potassium ferricyanide (red), and copper acetate (blue green).

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## NEW! STATIC ELECTRICITY GENERATOR

### Sturdy, Improved Model

See a thrilling spark display as you set off a miniature bolt of lightning. Sturdily made—stands 14" high. Two 9" plastic discs rotate in opposite directions. Metal collector brushes pick up the static electricity, store it in the Leyden jar type condenser until discharged by the jumping spark. 24 page illustrated booklet included.

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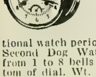
## Precision Marine Time Piece
## SHIP'S BELL CLOCK

### Faithful Time Afloat or Ashore



Handsome metal case in either brass or chrome. Highly corrosion resistant for use on shipboard or home. Finely made, unusually high quality. 8-day clock has familiar 1 to 12 dial—also marked with 24 hour system of timekeeping and traditional watch periods from Evening (or First) Watch through Second Dog Watch. Chimes nautical half-hour intervals from 1 to 8 bells (can be turned off). Thermometer at bottom of dial. Wt. 6 lbs.

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Useful to all outdoorsmen, especially sailors, shooters, fliers, golfers. Lightweight Pocket Wind Meter accurate to within 1 MPH. Two scales—low and high velocity. One from 2-10 MPH graduated in ½ MPH increments. Second from 10-66 MPH in 2 MPH increments. Easily read even in inclement weather. 6⅝" long x 1½" wide x ⅝" thick. Wt. approx. 2 ozs. Plastic pocket carrying case, instructions included.

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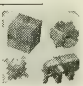

12 Different puzzles that will stimulate your ability to think and reason. Here is a fascinating assortment of wood puzzles that will provide hours of pleasure. Twelve different puzzles, animals and geometric forms to take apart and reassemble, give a chance for all the family, young or old, to test skill, patience and, best of all, to stimulate ability to think and reason while having lots of fun. Order yours now.

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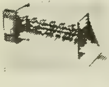
## SOLVE PROBLEMS! TELL FORTUNES! PLAY GAMES!
## NEW WORKING MODEL DIGITAL COMPUTER
### ACTUAL MINIATURE VERSION OF GIANT ELECTRONIC BRAINS



Fascinating new see-through model computer actually solves problems, teaches computer fundamentals. Adds, subtracts, multiplies, shifts, complements, carries, memorizes, counts, compares, sequences. Attractively colored, rigid plastic parts easily assembled, 12" x 3½" x 4¾". Incl. step-by-step assembly diagrams, 32-page instruction book covering operation, computer language (binary system), programming, problems and 15 experiments.

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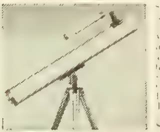
## See the Stars, Moon, Planets Close Up!
## 3" ASTRONOMICAL REFLECTING TELESCOPE

Photographers! Adapt your camera to this Scope for excellent Telephoto shots and fascinating photos of moon!

**60 to 180 Power — Famous Mt. Palomar Type! An Unusual Buy!**



See the Rings of Saturn, the fascinating planet Mars, huge craters on the Moon, Phases of Venus. Equatorial mount with lock on both axes. Aluminized and overcoated 3" diameter high speed f/10 mirror. Telescope comes equipped with a 60X eyepiece and a mounted Barlow Lens. Optical Finder Telescope included. Hardwood portable tripod. FREE with Scope: Valuable STAR CHART plus 272-page "HANDBOOK OF HEAVENS" plus "HOW TO USE YOUR TELESCOPE" BOOK

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Useful Telescope and Microscope combined in one amazing, precision instrument. Imported! No larger than a fountain pen. Telescope is 10 Power. Microscope magnifies 50 Times. Sharp focus at any range. Handy for sports, looking at small objects.

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**New! Lightweight! Strong! Versatile!**

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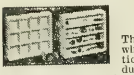

These precision-molded, one piece, white polystyrene trays are just the ticket for hobbyists, handymen, industry. Perfect for storing or displaying collections, holding household items, small industrial parts. Made of the same material used in ice buckets—won't warp, rot or discolor. Smooth skin makes them easy to clean. Recessed ledges of tray tops permit nesting. Special connector key permit locking together through dovetail key ways molded to sides of trays—make numerous wall displays and counter arrangements. Special sleeves of rigid white corrugated board make them into drawers . . . stack and you have low-cost cabinet. Make dust-proof display cases by cutting ordinary window glass or transparent plastic to fit snugly into recessed ledge. Inc. 3 ways w/12-compartments ea. meas. 2⅞"x2⅜"x2" and 3 trays w/4 compartments ea. meas. 10⅝"x2-1/16"x2". Both trays meas. 10⅝"x11⅝"x3" overall; wgt. 4½-oz.

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**CONNECTOR KEYS** for wall mounting or display trays—
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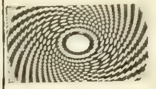

### Fascinating New Experimenters'
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### Fantastic Visual Effects! Limitless Applications

Now! Experiment with the amazing new tool of tomorrow. Basis of "OP ART" fabrics now sweeping the country in art, fashion, packaging, media. [illegible] for hobbyists, photographers, designers, lab and home experimenters. Fun! Profitable! Unlimited potential. Here's your complete introduction kit developed by Dr. Gerald Oster, Brooklyn Poly. Inst. Contains 8 basic patterns on both clear acetate lantern slide size 3¼" x 4" (.020 thick) and .012" thick white Kromekote paper 3¾" x 4½" (coated one side); two piece 3¼" x 4" 150-dot screen on film. Copy Dr. Oster's book, "The Science of Moire Patterns", an authoritative introduction to the fascinating world of moire.

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## NEW DE LUXE EXPERIMENTERS' MOIRE KIT "B"

Eight new totally different black and white patterns: Coarse lines, 65-line sines, perspective squares, medium grating, Gaussian grating; converging circles; elliptical zone plate; 30-line logarithmic spiral; plus instructions by Dr. Oster.

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## NEW JUMBO 20" x 25" MOIRE PATTERNS

Excellent for displays and signs. Write for details and prices.

MOIRE PATTERN ACCESSORY KIT. For additional experiments. Incl. metallic balloon, calcite, two kinds of diffracting gratings, one-way mirror foil, polarizing materials. Ronchi rulings, assortments of lenses.

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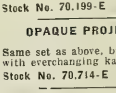
### Terrific Buy! American Made!
## OPAQUE PROJECTOR



Projects illustrations up to 3" x 3½" and enlarges them to 35" x 30" if screen is 6½ ft. from projector, larger pictures if screen is further away. No film or negatives needed. Projects charts, diagrams, pictures, photos, lettering in full color or black-and-white. Operates on 115 volt, A.C. current 6 ft. extension cord and plug included. Operates on 60 watt bulb, not included. Size 12" x 8" x 4½" W. 1 lb., 2 oz. Plastic case with built-in handle.

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## OPAQUE PROJECTOR WITH KALEIDOSCOPE ATTACHMENT

Same set as above, but provides endless additional projects with everchanging kaleidoscope patterns.

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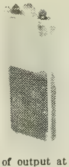
## NICKEL-CADMIUM BATTERY
### Unparalleled Value



For the first time a 6-volt, light-weight nickel-cadmium battery in stainless steel, strap type casing. 4-amp hour capacity. Almost unlimited life—thousands of discharge-charge cycles with minute deterioration—charges fully in approx. 1 hr. with Edmund charger kit. Just a few drops of water per year provide full maintenance. Hundreds of uses for hobbyists, amateur photographers, campers, model builders, etc. Unequalled for rechargeable lanterns; cycle scooters, and boat lights; portable fluorescent and ultra-violet lights; electronic flash units. Battery requires minimum of electrolyte; is sealed to prevent loss; delivers nearly 100% of output at below freezing temperatures compared to 50% by lead-acid batteries. No corrosive fumes under any stage of recharge. Can't be damaged by accidental charge in reverse (but not recommended). Stud type terminals on top 1⅛" apar, marked for polarity; 6/32 thread, nuts and lock-washers. 6"x2"4". Wt. approx. 2 lbs.

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**CHARGER KIT FOR 6-VOLT BATTERY.** Charges in approx. 1 hr. Shuts off automatically, attaches to Stock No. 70,766 battery case. Includes transformer, ballast resistors, charger circuit board, mounting hardware, 8-ft. cord, plug switch, assembly instructions.

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**EDMUND SCIENTIFIC CO., BARRINGTON, NEW JERSEY**

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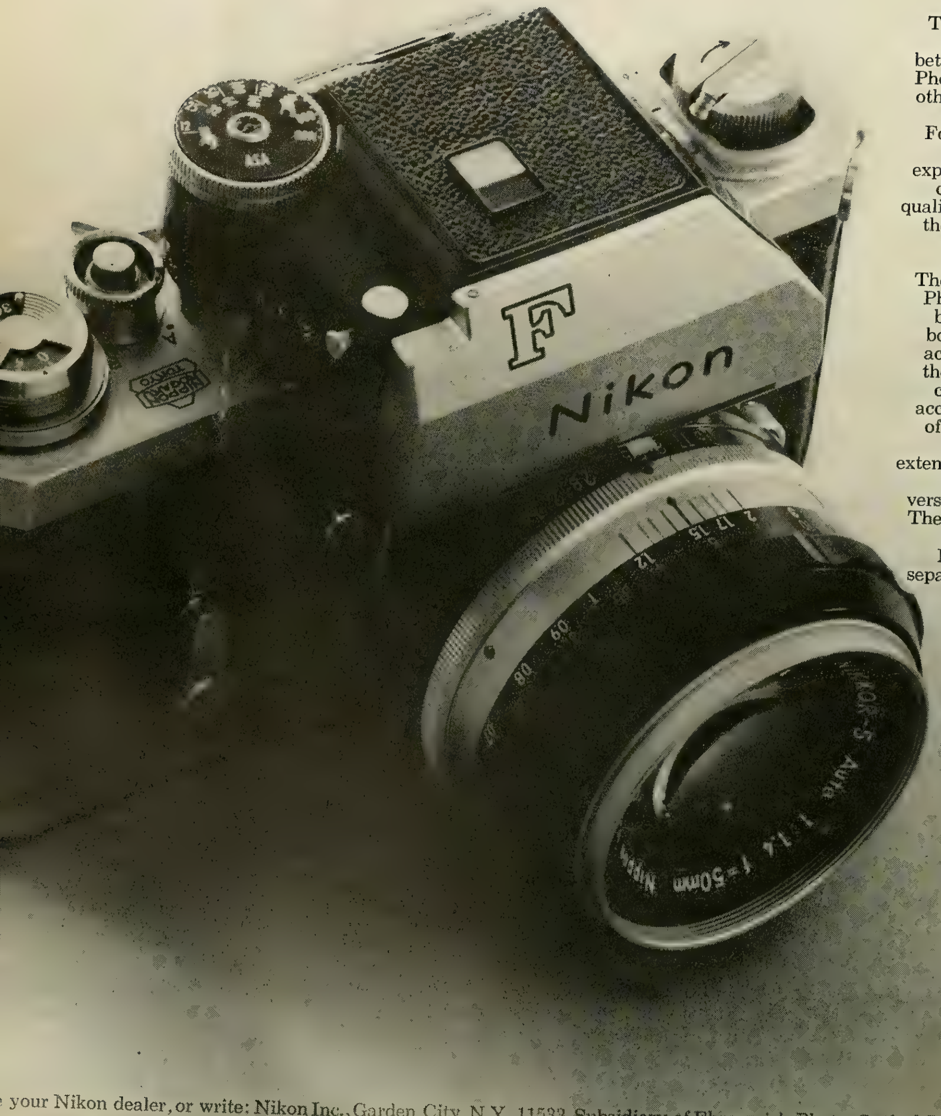
# The Camera Always A Nikon



This is the underlying difference between the Nikon Photomic T and all other thru-the-lens meter systems. For, whatever the importance of exposure accuracy, camera and lens quality still remains the most essential prerequisite for picture quality. The Nikon F with Photomic T combines the best of both. It links the accuracy of thru-the-lens exposure control with the accredited quality of Nikkor lenses. And it further extends the versatility of this most versatile of all 35's. The Photomic T is available with Nikon F or as a separate accessory.

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